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ELEMENTARY
MATERIA MEDICA

INCLUDING

DRUGS AND SOLUTIONS

A Text-Book for Students of Nursing

BY

WALTER W. KRUEGER, PH.B.
Instructor, The Grand Rapids Junior College

ILLUSTRATED

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FOREWORD

For a long time instructors and students in schools of nursing have felt the need of a text-book which treats, in an adequate, uncomplicated, and interesting manner, the subject-matter ordinarily included in an elementary course in Materia Medica.

Mr. Krueger's text-book of "Elementary Materia Medica" meets this need in every way. Throughout the text the author has shown a thorough understanding of nursing situations and has presented his material with a simplicity of style, a clearness and directness of expression seldom met in nursing texts treating on the subject of Materia Medica.

The chapter entitled "Historical Background of Modern Materia Medica," together with the numerous, well-selected illustrations, make the book one of unusual interest. The questions at the close of each chapter should be helpful to the student in reviewing content, while the comprehensive bibliographies should prove of value in assisting those students who desire a broader knowledge of the subject. The series of laboratory exercises and demonstrations contained in the final chapter are very practical and seem sufficiently flexible to be made adaptable to the needs of any individual class of students.

For these reasons this little book should prove useful as a text for student nurses in a course in Elementary Materia Medica.

Leila I. Given, R.N., M.S.
Instructor, School of Nursing,
Western Reserve University, Cleveland, Ohio.

PREFACE

The writing of this volume has been prompted by a desire to present a well-balanced, adequate account of the essential facts of elementary materia medica as clearly, concisely, and interestingly as possible. Every effort has been put forth to make the book scientifically accurate, to present the modern conceptions of the subject as proclaimed by the best authorities, and to include the necessary technical facts. The writer believes that general statements alone do not convey exact information and, therefore, has not avoided the use of technicalities. Students get many erroneous ideas when a subject is presented only in the form of general statements.

An attempt has been made to make the subject matter clear to the reader and to present it in the best pedagogical order. Emphasis has been placed upon the organization of the subject matter and a logical arrangement of the material within the chapters. The method of presentation and the arrangement used has been developed gradually during the past six years in the writer's classes at the Grand Rapids Junior College. It is hoped that this arrangement will prove itself well adapted to the needs of teachers and students at other institutions of learning.

To encourage students to make careful preparation for each assignment a set of questions has been appended at the end of most of the chapters. These questions have been devised to stimulate accurate study of technical facts. In addition to these questions it is desirable to call upon the students to discuss topics in connected discourse.

A bibliography has been added to most of the chapters. This serves the double purpose of indicating the authorities which have provided the writer with facts and inspiration, and suggesting to others authoritative sources of information for a fuller study of the various ramifications of the subject. The general bibliography in the appendix is arranged alphabetically by authors and includes the names of the publishers.

The first chapter serves as a general introduction to the subject of drugs and is followed by a discussion of the history of materia medica. It is hoped that these two chapters will arouse the student's interest in the study of drugs. Since animal drugs and biological products play an important rôle in modern materia medica, a chapter dealing with these preparations has been included.

Some students are inclined to look askance at anything with a mathematical mien. It should be made clear to the students that the arithmetic used in this work is ordinary arithmetic just as the arithmetic used in the business world is ordinary arithmetic, and not higher mathematics. Every student of nursing has had previous training in arithmetic but many require a thorough review before they can be relied upon to make accurate calculations. The chapter on arithmetic review provides a complete review of arithmetical processes that involve the various kinds of fractions.

The rules presented in the chapters dealing with the preparation of solutions and doses are standard rules involving standard arithmetical procedures. So-called "short-cuts," with their numerous exceptions and necessary modifications before they can be applied to the various purposes for which they were intended, are inimical to the best interests of the nursing profession. A rule that involves arithmetical processes that are not standard is confusing and should be avoided.

In the chapter dealing with weights and measures the metric system has been introduced from the historical standpoint to bring out the relationship between the various units, and the fact that it is a system that has been carefully planned by men of scientific training. In the chapter on antiseptics and disinfectants the writer has attempted to give an adequate discussion of these important agents, including the modern conceptions concerning their modes of action and comparative values.

Much interest may be added to the subject by means of illustrative material suitable for demonstration purposes during the class and laboratory periods. Directions for laboratory work and demonstrations have been grouped together in a separate chapter. This arrangement facilitates their use or modification to meet the particular requirements of the class. If the laboratory work must be curtailed for lack of time or facilities, it is suggested that material for demonstration purposes during the class period be provided.

It is with great pleasure that the writer acknowledges his indebtedness to two of his colleagues, namely, Miss Lauretta Morrisey for reading the manuscript and offering valuable suggestions, and Miss Lillian Leeson for reading the manuscript and tendering helpful encouragement. The writer is also indebted to Miss Elizabeth Watson of Blodgett Memorial Hospital, Grand Rapids, Michigan, for reading and checking parts of the manuscript. The writer's thanks are likewise due to Reed and Carnrick for permission to reproduce illustrations from their booklet "Disguising Distasteful Drugs;" to Hygeia, the Health magazine, published by the American Medical Association for furnishing the illustration of Hygeia and Æsculapius; to Battle and Company for permission to use the illustration of Galen; and to the Century Company and Mr. H. C. Fuller, publisher and author respectively of "The Story of Drugs," for permission to reproduce certain illustrations.

It is the sincere hope of the writer that, despite shortcomings, these pages will bring to the student a thorough understanding of a body of facts essential to the mental equipment of the nurse. Any criticisms or suggestions for the improvement of the book, when revised, will be received with appreciation.

WALTER W. KRUEGER.

GRAND RAPIDS, MICHIGAN.

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Elementary Materia Medica

CHAPTER I

INTRODUCTION

General Considerations.
Purposes for Which Drugs Are Used.
Sources of Drugs.
Materia Medica and Its Subdivisions.

GENERAL CONSIDERATIONS

From the dawn of history man has been interested in drugs and other remedial agents for the relief of his ills. This interest has been rewarded in the finding of drugs that have proven themselves of great value to mankind. Drugs are no longer used haphazardly, as they were in the past, but are now used to produce very definite effects in the prevention, alleviation, and cure of disease. The subject of Elementary Materia Medica will introduce the student to the present day knowledge of drugs, concerning their sources, nature, history, and effects. The solubility of drugs, the preparation of solutions, methods of weighing and measuring, and the laws relating to the sale and use of drugs will also be considered.

The term *drug* was formerly applied only to dried plants that possessed medicinal value, and is still used in that sense by some writers. The definition most commonly applied to the term at the present

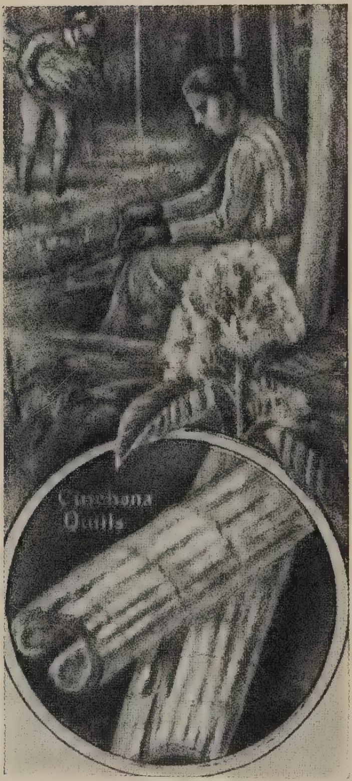


FIG. 1.—Cinchona quills. (Courtesy of Reed and Carnrick.)

time, however, is that it is any substance other than a mechanical agent used in the treatment of disease. This includes vaccines, antisera, extracts of animal organs, plant and mineral materials, as well as the synthetic substances made in the chemical laboratory. When a drug is in a form suitable for administration to the patient, it is termed a *medicine.* When it is used in doses that produce harmful effects it is a *poison.*

PURPOSES FOR WHICH DRUGS ARE USED

Drugs are used by the physician for four main purposes, (1) to prevent disease, (2) to relieve distressing symptoms, (3) to help the body regain its normal functions, and (4) to remove the cause of disease. Examples of drugs used to *prevent disease* are, toxin-antitoxin for diphtheria, iodine for goiter, and smallpox and typhoid vaccines. Drugs used to *relieve distressing symptoms* are, morphine which relieves pain, epinephrine which may be used to stop hemorrhage, and stramonium which relieves the spasms in asthma. Among drugs used to help the body *regain its normal functions* are, iron salts which cause a regeneration of the blood, strychnine which stimulates the nervous system and respiratory center, and digitalis which helps a diseased heart to compensate for its defects. Drugs which *remove the cause of disease* include, quinine in malaria, mercury and arsphenamine in syphilis, and diphtheria antitoxin in diphtheria.

SOURCES OF DRUGS

The three kingdoms of Nature, *plant, animal,* and *mineral,* provide us with drugs. Many *plants*

Fig. 2.—Digitalis. (Courtesy of Reed and Carnrick.)

contain valuable medicinal principles which may be found in the leaves, roots, bark, seeds, flowers, juices or in the whole herb. The parts of the plant that are of medicinal value are gathered and dried before being made into medicines. In the dried form they are known as *crude drugs*. Many parts of the world contribute to the drug supply of civilized nations.

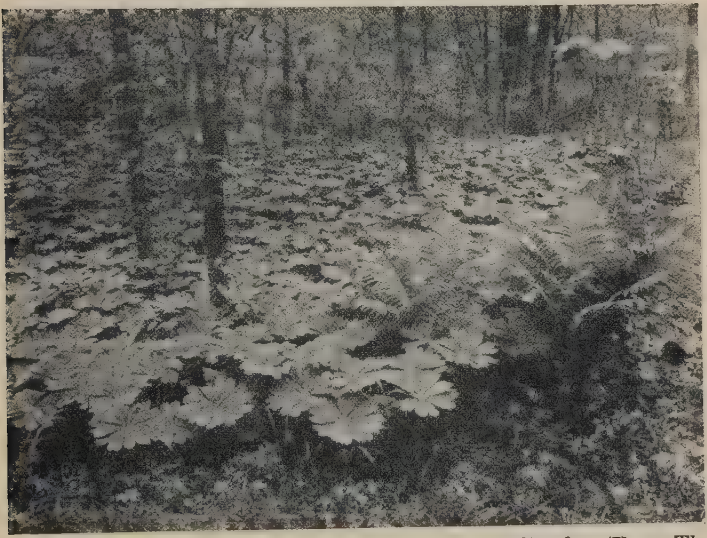


Fig. 3.—Mandrake or may apple in its native woodland. (From The Story of Drugs by H. C. Fuller, Century Co., Publishers.)

Table of Botanical Drugs

1. Drugs Native to North America

Cascara Bark
Mandrake Root (May Apple)
Wintergreen Leaves
Peppermint Herb
Wild Cherry Bark
Hydrastis (Golden Seal)

2. Foreign Drugs Now Cultivated in the United States

Aconite (Europe)
Digitalis Leaves (Europe)
Belladonna Leaves (Europe)
Eucalyptus Leaves (Australia)

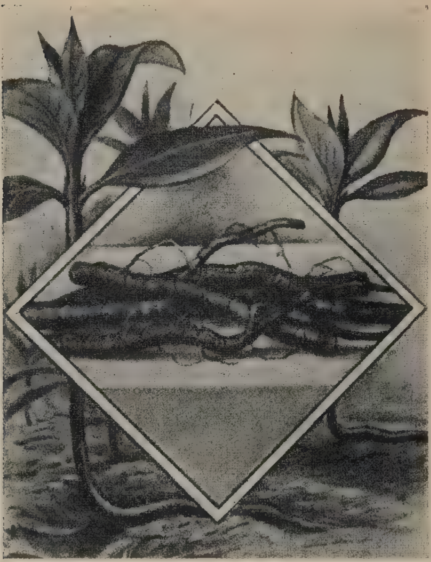


FIG. 4.—Ipecac. (Courtesy of Reed and Carnrick.)

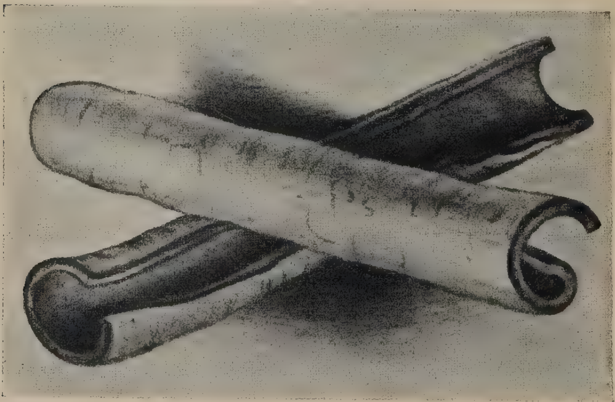


FIG. 5.—Cascara bark. (Courtesy of Reed and Carnrick.)

3. Foreign Drugs Imported in the Crude Form

Cinchona Bark (S. America)
Hyoscyamus Leaves (Europe)
Licorice Root (Europe and Asia)
Sandalwood (India and Madras)
Strophanthus Seeds (Africa)
Coca Leaves (Peru)
Ergot (Spain and Russia)
Rhubarb (Asia)
Gentian Root (Europe)
Jaborandi Leaves (Brazil)
Nux Vomica Seeds (India, Ceylon and Siam)
Senna Leaves (Egypt and Arabia)
Opium (Turkey and Persia)
Aloes (Dutch West Indies)
Ipecac (Brazil)
Squill (Europe)

Fig. 6.—A field of the opium poppy. (From The Story of Drugs by H. C. Fuller, Century Co., Publishers.)

Examples of medicinal agents obtained from the *animal kingdom* are cod-liver oil, pepsin, pancreatin, epinephrine, thyroxin, pituitary extract, and insulin.

A large number of valuable drugs are obtained from the *mineral kingdom.* Iodine is obtained largely from the saltpeter beds in Chili. Mercury is obtained

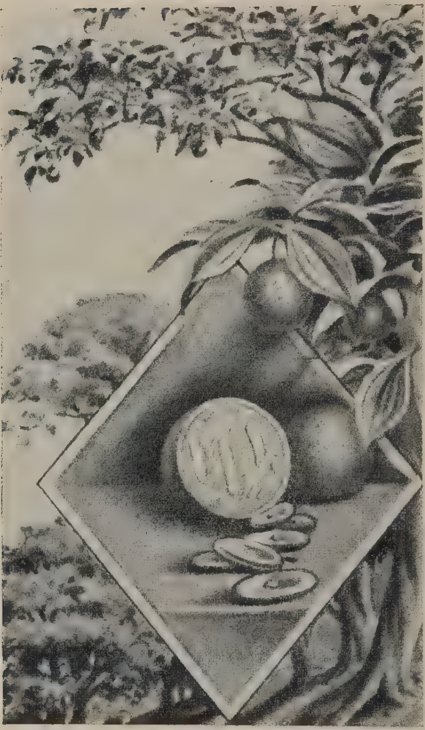


FIG. 7.—Nux vomica. (Courtesy of Reed and Carnrick.)

from cinnabar which is mined in California, Texas, and Sicily. Arsenic is a by-product in the smelting of copper, silver, and gold. Boric acid is obtained from crude borax in the United States. Other useful mineral drugs are salts of iron, silver, zinc, and magnesium.

Many drugs in use at the present time are complex chemical compounds made *synthetically* in the chemical laboratory. Examples of these are arsphenamine, procaine, acriflavine, and mercurochrome. Many useful drugs are obtained from *coal tar* by fractional distillation. Coal tar is a mixture of many substances which may be separated from one another when the tar is subjected to fractional distillation. In some instances the coal tar derivatives are combined with other substances to make new compounds which did not exist in the coal tar. Such substances are synthetic preparations and, although, not strictly coal tar products are usually spoken of as such. Examples of coal tar products are carbolic acid, the cresols, salicylic acid, phenolphthalein, aspirin (acetylsalicylic acid), acetanilid, methylene blue, gentian violet, and resorcine.

In the *bacteriological laboratory* various vaccines and antisera are produced, the most important of which are smallpox and typhoid vaccines, and diphtheria antitoxin.

MATERIA MEDICA AND ITS SUBDIVISIONS

Materia Medica (Lat., *medical materials*) treats of the materials used as medicines. It includes the study of their sources, physical and chemical properties, actions, preparations, uses, doses, and methods of administration.

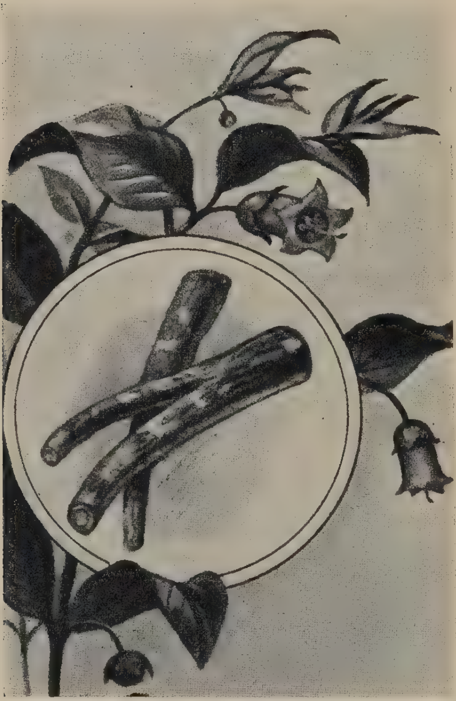


FIG. 8.—Belladonna. (Courtesy of Reed and Carnrick.)

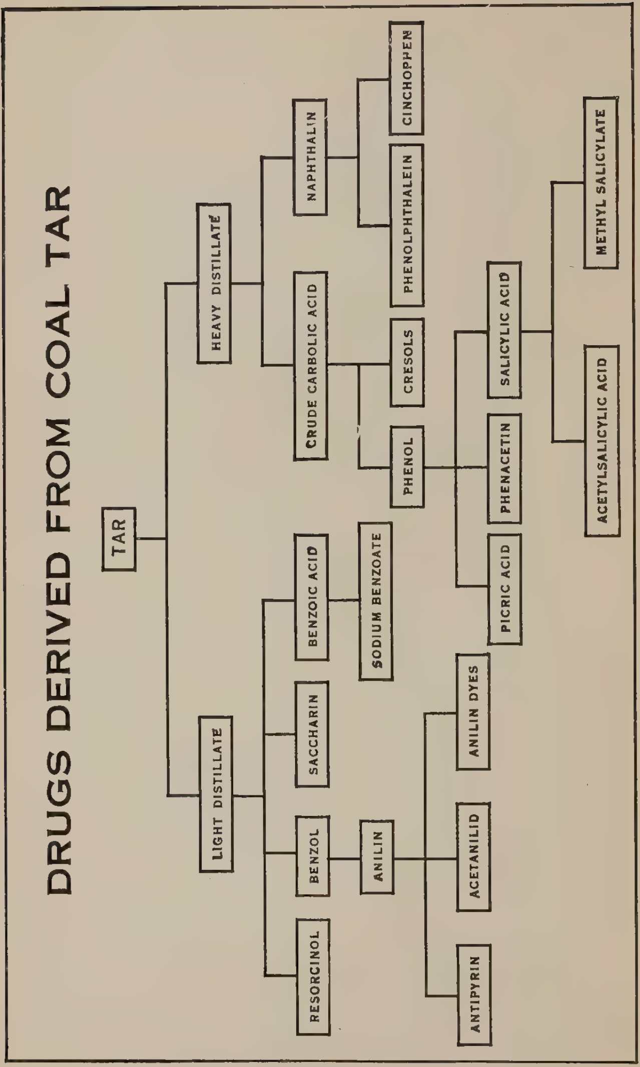
Pharmacognosy is a branch of Materia Medica which treats of crude plant drugs. It includes a study of their structure and chemical characteristics for purposes of identification and the determination of their quality and purity.

Pharmacology deals with the action of drugs on the living body. This knowledge is obtained through the clinical experiences of physicians and also through the observation of the action of drugs on animals.

Therapeutics deals with the methods used in the treatment of disease. It includes the use of (1) drugs (*drug therapy*); (2) physical agents (*physical therapy*), such as electricity, radium, *x*-rays, massage, water, heat, and cold; (3) dietetic measures (*dietetic therapy*); and (4) mental suggestion (*psychotherapy*).

QUESTIONS FOR CLASS DISCUSSION

1. What is a drug? A medicine?
2. State the main purposes for which drugs are used and give examples.
3. What is a crude drug?
4. State the common sources of drugs and give examples.
5. Name some botanical drugs native to North America.
6. Make a general statement concerning the geographical sources of drugs.
7. Name five plants of which the leaves are used in medicine. Name three roots.
8. Name two drugs that are the bark of trees or shrubs.
9. Name five drugs of animal origin and tell from what part of the body they are derived.
10. Name five drugs obtained from the mineral kingdom.
11. State the difference between an organic and inorganic drug and give an example of each.
12. What is a synthetic drug?
13. What is meant by a coal tar product?
14. Give the names of drugs that are derived from coal tar.



DRUGS DERIVED FROM COAL TAR

15. What kinds of medicinal preparations are obtained from the bacteriological laboratory?

16. Define, (*a*) materia medica, (*b*) pharmacognosy, (*c*) pharmacology, and (*d*) therapeutics.

17. Mention the branches of therapeutics.

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CHAPTER II

HISTORICAL BACKGROUND OF MODERN MATERIA MEDICA

- PREHISTORIC AGES.
- ANCIENT PERIOD.
  - Egypt.
  - Greece.
  - Rome.
- MEDIEVAL PERIOD.
  - Early Christian Era.
  - Arabian Influence.
  - Rise of the Universities.
  - Later Middle Ages.
- MODERN PERIOD.
  - Paracelsus and Cordus.
  - Seventeenth and Eighteenth Centuries.
  - Nineteenth Century.
  - Recent Progress.

PREHISTORIC AGES

The beginnings of Medicine reach far back into the prehistoric ages of man. Primitive man attributed disease as well as other calamities to evil spirits. He believed that unseen living beings were continually surrounding him. Some of these were good spirits while others were bad spirits. Pain, swelling, abscess, and in fact every ill to which human flesh was heir, was in his opinion caused by evil spirits who invaded the body. The treatment of disease was designed to drive these spirits from the body. This was done by appealing to the good spirits in the form of prayers and sacrifices; and by means of noises, incantations, and disagreeable tasting drugs. Civilized man has not entirely shaken off the superstition and mysticism which was so intimately associated with the life of his remote ancestors.

From a crude beginning the healing art fought its way up through centuries of ignorance and superstition, until it has become a preëminent science. Its story is a faithful expression of the progress of humanity.

ANCIENT PERIOD

Egypt.—The oldest medical book in the world is an Egyptian papyrus which was written in the seventeenth century B.C., before the days of Moses and Tutankhamum. It was recently discovered in the coffin of an Egyptian physician and is now in the possession of the New York Historical Society. It is in the form of a scroll many yards in length and contains clinical reports, recipes for making medicines, magic formulæ, and exorcisms.

Many of the recipes included drugs that are still in use today, such as, castor oil, wormwood, aloes, peppermint, opium, henbane, squill, and turpentine. The Egyptians also used minerals such as lead, iron, sodium carbonate, and copper. Precious stones were used in a finely pulverized form. The fat and blood of many different kinds of animals, as well as their hoofs, horns, and hides were also used.

The pharmacist of this period made pharmaceutical preparations of these drugs in the form of pills, powders, infusions, decoctions, salves, plasters, and confections. Some of the recipes contained as many as thirty-five ingredients. It is believed that the Egyptians used the juice of the poppy and Indian hemp to make the patient drowsy before a surgical operation. The physicians were priests and the healing art was, therefore, closely associated with religion.

Many of the Egyptian drugs later found their way into the materia medica of the Greeks and from Greece they were passed on to other nations.

Greece.—The medical and pharmaceutical lore of Greece begins with the mythology of that period for the Greeks attributed the origin of the healing art to their gods. In the early history of the Greeks it is at times difficult to tell whether certain characters were legendary or real. The most important legendary character was Æsculapius, son of Apollo, who taught man the art of healing. The Greeks built temples, in his honor, in which the art of healing was further developed. Æsculapius is usually pictured

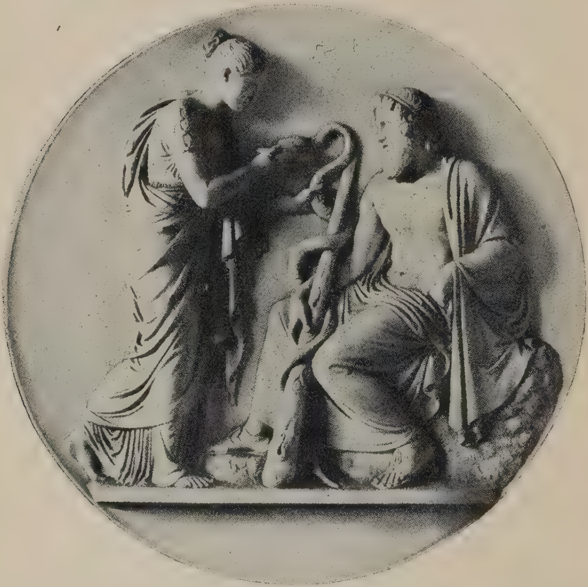

FIG. 9.—Hygeia and Æsculapius. (Courtesy of Hygeia, the Health Magazine.)

holding a staff around which a snake is coiled. The snake was an emblem of wisdom among the Greeks and Egyptians. The emblem known as the *caduceus* in which there is a snake coiled around a staff, is still a medical insignium used at the present time.

Hygeia, the goddess of health, was a daughter of Æsculapius. Another daughter, Panacea, represented medicine. Other mythical characters of interest to the student of drugs were Morpheus, the god of dreams (origin of word morphine), Somnus, the god of sleep (origin of term somnifacient) and Chiron the originator of the art of pharmacy.

The physician-priests who practiced the art of healing in the temples of Æsculapius were called Æsclepiades. The temples were in reality hospitals and were usually located in beautiful surroundings. Prayers, incantations, charms, and the interpretation of dreams that came to the patient while asleep before the altar, played a part in the treatment. Drugs were also used.

In the fifth century B.C., Hippocrates, one of the great characters in history, made his appearance. Greek medicine, which was to have such a profound influence throughout the world in the centuries that followed, began with Hippocrates. He believed that accurate observation of actual phenomena should be the basis of all knowledge. He taught that disease resulted from natural causes, rather than supernatural, and that it should be treated with natural remedies rather than by magic.

He also believed that nature had the power to cure disease (*vis medicatrix naturœ*) and that the physician should aid the natural recuperative powers of the patient with drugs, diet, sunlight or by other means. He carefully studied the symptoms of diseases and his recorded observations of certain diseases are still found to be correct. Among the pharmaceutical preparations used by Hippocrates were poultices, suppositories, pills, lozenges, ointments, cerates, and gargles.

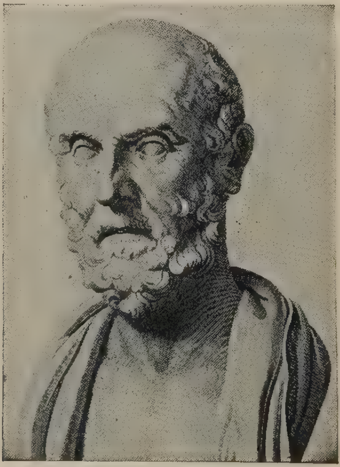

Fig. 10.—Hippocrates (460–377 B.C.).

Because of the importance of the work of Hippocrates in establishing the practice of medicine upon sound principles he is spoken of as the "Father of Medicine." The idealistic code known as the Hippocratic Oath was formulated by Hippocrates and is still administered to the graduates of medical schools at the present time.

Another Greek physician was Dioscorides who was noted for his work on Materia Medica. He carefully described several thousand drugs. His work remained a recognized authority for over 1500 years.

Rome.—Six centuries after the time of Hippocrates, in the early Christian Era (about 150 A.D.), Greek medicine was introduced into Rome by Galen, a Greek physician. Galen possessed great literary skill and through his writings exerted a profound influence on medicine and pharmacy. His writings included clinical observations, anatomy, physiology, pathology, diagnosis, therapeutics, and many other topics.

Fig. 11.—Claudius Galen. (131–201 A.D.) (Courtesy of Battle and Company.)

He accepted in general the theories and methods of Hippocrates upon which he built a system of medicine and pharmacy which became the supreme authority and flourished until the beginning of modern science in the seventeenth century. Even in the seventeenth century many physicians would not use drugs not recommended in Galen's writings. He thus dominated the medical world for 1500 years.

Galen originated many preparations of vegetable drugs. The name "galencial preparations" was applied to these and is still used by pharmacists at the present time. He added ointment of rose-water (cold cream) to the materia medica. As an example of the soundness of Galen's teachings it may be said that he recommended fresh air, milk and eggs as the best treatment for tuberculosis.

MEDIEVAL PERIOD (400 TO 1500 A.D.)

Early Christian Era.—The downfall of Rome was followed by a period in which the spread of Christianity was an important factor. The term Dark Ages is sometimes applied to the first six centuries of the Christian Era because culture and progress declined during this period. A condition of stagnation existed in all fields of scientific learning.

Religious Orders arose in which the spark of learning was kept alive. The monasteries and convents of the Benedictine Order became scattered all over Europe. The practice of medicine was largely in the hands of monks, particularly those of the Benedictine monasteries. The monks were not permitted to shed blood, so the practice of bloodletting and surgery was turned over to the barbers. In the gardens of the monasteries medicinal herbs were cultivated. One of the pharmaceutical preparations that came into use at this time was "ointment of the twelve apostles" which contained twelve ingredients.

Arabian Influence.—In the eighth century the Arabs swept over Palestine, Egypt, North Africa, Spain and some of the islands of the Mediterranean Sea near Italy and Greece. The works of Hippocrates and Galen were translated into Arabic and furnished the basis of Arabic medicine. The Arabs produced many able students and were particularly interested in medicine, pharmacy, and chemistry. Arabian physicians and apothecaries became prominent. Avicenna was the greatest among the Arabian physicians. He lived in the tenth century at the height of the Arabian influence. His book "The Canon" was one of the most important medical text-books in Europe for centuries. He is sometimes called the Arabian Galen.

The Arabs introduced a number of new vegetable drugs, such as senna, rhubarb, camphor, aconite, sandalwood, and cannabis. They made important advances in chemistry and introduced many mineral medicines such as antimony, iron, silver nitrate, nitric acid, and mercuric chloride. The advance in pharmacy and in the therapeutic use of drugs stimulated the writing of many books containing formulæ of medicinal preparations. Such books are now called pharmacopœias. The Arabs produced the first pharmacopœia.

Pharmacy was separated from the healing art and became an independent art. Many pharmacies arose in which pharmaceutical preparations were compounded and sold. Mohammedan influence over medicine and pharmacy continued through the Middle Ages.

Rise of Universities.—In the ninth century, during the reign of Charlemagne, the first medical school of the Middle Ages was established at Salerno in Southern Italy. This part of Italy had been settled by Greeks, who continued to speak the Greek language. Salerno became the center of medical learning. Both men and women were members of the faculty. Women were also permitted to practice medicine in Italy.

The course of study was three years of preliminary study and four years of medicine. Pharmacy was taught in connection with medicine. A popular health code was issued by the University in which diet, rest and the influence of the mind upon the body were given as important factors in the regulation of health.

Greek culture was also kept alive in Southern France where the University of Montpellier was established. It was primarily a medical school and is still in existence at the present time. Later many universities under ecclesiastical control were established throughout Europe.

Late Middle Ages.—In the twelfth century a Benedictine Abbess known as St. Hildegarde wrote several books on medicine. She became a center for the intellectual life of her time and is regarded as the most important medical writer of her period.

Epidemics of various diseases were prevalent in Europe during the thirteenth and fourteenth centuries. The Black Death (bubonic plague) took the lives of about sixty million people during this period.

In the fourteenth century *alchemy*, which originated with the Arabs, became popular in Europe. It was a search for the Elixir of Life, which it was supposed could ward off all disease; and the Philosopher's Stone, which it was thought could transmute the baser metals into gold. Alchemy later led to the establishment of certain fundamental principles which gave rise to the development of chemistry as a science.

Throughout the Medieval Period the works of Hippocrates, Galen, Dioscorides and Avicenna were regarded as authoritative. Respect for authority was the order of the day.

MODERN PERIOD

Paracelsus and Cordus.—With the sixteenth century came the renaissance of learning, and with it the beginning of modern medicine and pharmacy. This century produced Paracelsus, a Swiss physician, who received training in both medicine and chemistry. The old authorities were still held in esteem but Paracelsus stood for independent thinking and study and taught that knowledge should be gained from experience. To show his contempt for the old authorities he publicly burned Avicenna's "Canon" and the works of Galen and Hippocrates, while he was professor of medicine at the University of Basle.

He stimulated men to think. He denounced the work of the alchemists and pointed out that chemistry should be directed toward the making of medicines and not gold. A number of new remedies, such as calomel and sulphur, were introduced by him. He investigated many chemical substances and wrote many books.

Another personage of importance at this time was Valerius Cordus who published a pharmacopœia which became quite popular. The formulæ were selected largely from Greek, Roman and Arabian books. It became the official pharmacopœia in the city of Nuremberg and was in great demand throughout Europe. Among the pharmaceutical preparations it contained were confections, syrups, purges, pills, lozenges, plasters, ointments, and cerates. It held its place for more than one hundred years and stimulated the publication of pharmacopœias in many

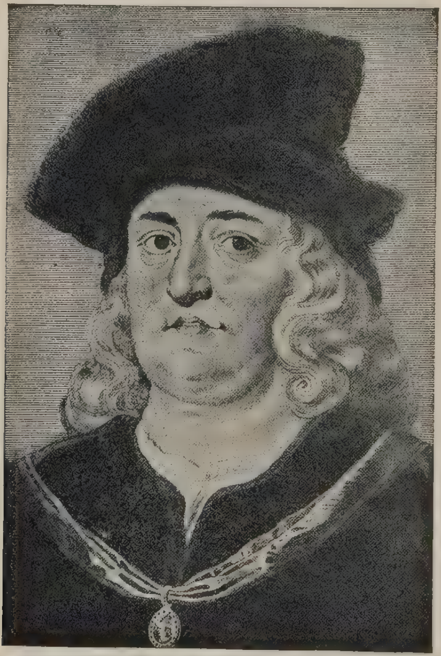

FIG. 12.—Paracelsus (1493–1541).

cities. Later the city of Augsburg issued a pharmacopoeia which came to be accepted as the highest authority of the sixteenth century.

Seventeenth and Eighteenth Centuries.—The first London Pharmacopœia appeared in the seventeenth century and became the official book of drugs throughout Europe. It was based largely upon the works of the Arabians and of Galen and contained more than nineteen hundred remedies. Some of the formulæ contained precious stones, oil of wolves, foxes' lungs, and many other strange preparations. One of the formulæ called for 130 ingredients.

Much progress was made in chemistry and pharmacy during this period. Many of the preparations which are still in use today originated during the seventeenth century. Among these were compound infusion of senna, laudanum (tincture of opium), Rochelle Salt, Epsom Salt and boric acid. Cinchona bark, which the Indians of Peru found to be of value in the treatment of malaria, was introduced into Europe. The active principle of this bark is quinine which is still used in the treatment of malaria. Other drugs introduced into Europe from America were coca leaves from Peru, ipecac from Brazil and jalap from Mexico.

In the eighteenth century inoculation against smallpox was introduced. Edward Jenner an English physician had noticed that milkmaids who frequently became infected with cowpox were immune to smallpox. He experimented by vaccinating people with the virus taken from the hands of milkmaids who had become infected with cowpox. It proved to be effective and the practice became established.

Infusion of digitalis was introduced by Dr. William Withering of England in the treatment of heart disease. Dover's Powder came into existence containing practically the same ingredients that it does today. Fowler's solution, introduced in 1786, is one of the Pharmacopœial preparations of the present day.

Fig. 13.—Edward Jenner (1749–1823). (From the painting by Sir Thomas Lawrence.)

In America many drugs used by the Indians found their way into the materia medica of the colonists. Examples of these are golden seal (hydrastis), May apple (mandrake), Indian tobacco (lobelia), bloodroot and slippery elm. The materia medica of the American Indian was quite extensive, containing several hundred native drugs. Many physicians of the eighteenth century used secret medicines. This gradually developed into the "patent" medicine traffic of the present time.

Nineteenth Century.—Enormous strides were made during this period. Chemistry developed into a highly specialized science and many medicinal substances were investigated by chemists. This work soon bore fruit in the isolation of the active principles of many vegetable drugs. In 1815, Serturner, a German apothecary, isolated *morphine* from opium. This was the first active principle of a drug to be obtained. Later *strychnine* was isolated from nux vomica seeds, *quinine* from cinchona bark, *emetine* from ipecac, *atropine* from belladonna, and *cocaine* from coca leaves. The isolation of the pure active principles was of very great importance for it made possible the accurate study of the effect of dosage.

The chemical study of coal tar resulted in products such as salicylic acid, benzoic acid, acetanilid, and antipyrin. It was discovered that cocaine could be applied locally to produce local anesthesia. Ether was first used as a general anesthetic in 1842 by Dr. Crawford Long of Georgia. Iodine was discovered in the ashes of seaweeds.

The bacteriological discoveries of Pasteur led Lister, an English surgeon, to suspect that bacteria were the cause of certain disease processes, particularly wound suppuration, septicemia, gangrene, and other conditions that frequently followed operations. He began to apply chemical antiseptics to surgical wounds and obtained a high percentage of recoveries among his patients. He thus gave rise to the use of antiseptics.

During this century accurate methods of studying the action of drugs on animals developed. New drugs were first tried on animals before being administered to human beings. Old drugs were also tested in this way and many were discarded as useless. This has placed the use of drugs on a firm scientific basis.

In 1818 the French Codex, which was the first national pharmacopœia, appeared. The pharmacopœias mentioned previously were issued by cities and were therefore not national in their scope. Two years later the first edition of the United States Pharmacopœia was issued. The British and German pharmacopœias also appeared during this century.

FIG. 14.—Sir Joseph Lister (1827–1912).

Due to the large number of chemical substances that found their way into the materia medica of civilized nations, the manufacture of medicinal chemicals became an important industry. Manufacturing pharmacists were established and many pharmaceutical preparations were made in large quantities with the aid of special machinery. The druggist no longer had to compound all the preparations that he dispensed.

Diphtheria antitoxin was introduced by Behring in 1890. This lowered the death rate of diphtheria from forty to about six per cent.

FIG. 15.—Paul Ehrlich (1854–1915). Pioneer in studies on immunity.

Recent Progress.—Science has made remarkable progress since the beginning of the twentieth century. Many biological preparations such as typhoid vaccine and antitoxin against scarlet fever came into use. Many kinds of vaccines and antisera are now in daily use. In 1907, Ehrlich, a German physician, produced salvarsan (arsphenamine) which proved to be a valuable therapeutic agent in the treatment of syphilis.

More recently thyroxin, the active principle of the thyroid gland was isolated and also made synthetically. Epinephrine was isolated from the suprarenal glands and its synthetic manufacture was also accomplished.

Many dye substances have come into use in the treatment of internal infections such as septicemia, peritonitis, and certain diseases of the kidneys. Examples of these are gentian violet and acriflavine.

One of the most important discoveries was made by Banting in 1922 when he succeeded in obtaining insulin from the Islands of Langerhans in the pancreas. Insulin has been found to be of great value in the treatment of diabetes.

The use of vaccines, antisera and drugs administered hypodermically have superseded many of the older methods in medical practice.

Questions for Class Discussion

1. Of what did the materia medica of primitive man consist?
2. Name some of the drugs used by the ancient Egyptians.
3. Who was Æsculapius?
4. Why is Hippocrates considered a great character in history? When did he live?
5. Of what importance was Galen?
6. What was the condition of medicine in the Dark Ages?
7. What is the period of Arabian influence?
8. What contributions to medicine did the Arabs make?
9. What was alchemy?
10. Which writings remained authoritative throughout the Medieval Period?
11. What contributions did Paracelsus make to medicine?
12. Who introduced vaccination against smallpox? When?
13. Name some important drugs introduced during the eighteenth century.
14. Give the important developments of the nineteenth century.
15. What is the modern trend concerning the use of drugs and the kinds of drugs used?

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CHAPTER III

THE PHARMACOPŒIA AND OTHER STANDARD BOOKS

Pharmacopœia.	New and Non-Official Remedies.
National Formulary.	
Dispensatories.	

PHARMACOPŒIA

Each civilized nation has an authoritative book which establishes standards for drugs and medicinal preparations. Such a book is usually called a *pharmacopœia.* The United States Pharmacopœia is an authoritative book containing a list of drugs and preparations, with definitions, descriptions, tests, and formulæ for their preparation. It has established standards of quality and purity for the drugs and ingredients used in the formulæ it contains. It also gives tests which may be used to establish the identity of a drug and describes processes of manufacture and preparation. Since the Pharmacopœia is a book of scientific character prepared by the official representatives of the medical and pharmaceutical professions, the drugs and preparations it contains are spoken of as being *official.*

Each drug and formula is given a Latin and English title. In plant drugs the scientific botanical name is given while in the case of chemicals the symbolic formula is given. To serve as a guide to pharmacists and physicians, it gives the average approximate dose in the metric and apothecaries', systems.

The Pharmacopœia is revised every ten years by a committee appointed by the National Pharmacopœial Convention which meets at Washington, D. C. Delegates are sent to this convention from medical, pharmaceutical and chemical organizations, such as the Medical Department of the Army and Navy, the American Medical Association, the American Pharmaceutical Association, the American Chemical Society, the American Drug Manufacturers' Association, etc. The convention selects a committee of fifty-one members to carry out the work of revision.

The Pharmacopœia is of value to the physician as well as the dispensing pharmacist. It makes it possible for the physician to make use of the modern materia medica. If a physician prescribes an official preparation he knows that it can readily be supplied by the pharmacist and that it will be of standard strength. The tenth revision of the United States Pharmacopœia (abbreviated, U.S.P. X) is now in effect.

NATIONAL FORMULARY

The National Formulary (abbreviated, N.F.) contains formulæ for pharmaceutical preparations that are in general use but not included in the Pharmacopœia. It is published by the American Pharmaceutical Association. It provides standards for the preparations it contains and gives directions for tests for identity and purity. It has become a very important book in recent years both for the pharmacist and the physician.

Both the U.S.P. and the N.F. have been made *legal standards* by the Federal Food and Drug Act of 1906. This places the N.F. practically on a par with the U.S.P. A drug or medicinal preparation sold by a name recognized in the U.S.P. or N.F. must conform to the standards of strength and purity given in these books. Usually only the preparations in the U.S.P. are spoken of as official, but some authors of pharmaceutical books speak also of N.F. preparations as official. The fifth edition (N.F.V.) is now in effect.

DISPENSATORIES

A dispensatory is a commentary on a pharmacopœia or other books containing medicinal formulæ. It discusses the formulæ and gives an account of the sources, mode of preparation, physiological action and therapeutic uses of the preparations given in these books. It is of great help to the pharmacist to have a reliable commentary upon the U.S.P. and N.F. In the United States there are three books called dispensatories, namely, the United States Dispensatory, the National Standard Dispensatory and the American Dispensatory.

NEW AND NON-OFFICIAL REMEDIES (N.N.R.)

The Council on Pharmacy and Chemistry of the American Medical Association publishes this book annually. It lists drugs of a proprietary nature as well as certain non-proprietary preparations that are in common use and appear to be of value. It provides standards as far as possible for these preparations. Many of these preparations at the present time are synthetic and biological products. The American Medical Association maintains a laboratory where products submitted to it are examined to determine their therapeutic value.

Questions for Class Discussion

1. What is a pharmacopœia?
2. Discuss briefly the United States Pharmacopœia.
3. What is meant by an official drug or preparation?
4. Who has charge of revising the U.S.P.?
5. What is the present standing and purpose of the N.F.?
6. What is a dispensatory? Name the dispensatories published in the United States.
7. What is the purpose of N.N.R.? Who publishes it?
8. Which of the above books are legal standards?

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CHAPTER IV

PHARMACEUTICAL PREPARATIONS

- Solid Preparations.
  - Powders.
  - Pills.
  - Tablets.
  - Lozenges.
  - Ointments.
  - Cerates.
  - Pastes.
  - Plasters.
  - Suppositories.
- Extractives.
  - Extracts.
  - Fluidextracts.
  - Tinctures.
  - Infusions.
  - Decoctions.
- Aqueous Solutions.
  - Waters.
  - Solutions.
  - Muscilages.
  - Syrups.
- Alcoholic Solutions.
  - Spirits.
  - Elixirs.
- Suspensions.
  - Mixtures.
  - Emulsions.
- Miscellaneous Preparations.
  - Liniments.
  - Glycerites.
  - Collodions.
  - Capsules.
  - Ampules.

Pharmaceutical preparations are drugs in a form suitable for therapeutic use. The making of these preparations is the work of the pharmacist. Pharmacy deals with the art of preparing and dispensing medicines. Many different methods are employed in the manufacture of the various pharmaceutical preparations.

SOLID PREPARATIONS

Powders (*pulvis, pulveres*) are finely subdivided preparations of drugs. Official powders are usually mixtures of several drugs and are termed compound powders. Sometimes powders are mixed with effervescent salts. Such powders are given in water and the carbon dioxide liberated makes them quite agreeable to the palate.

Compound Chalk Powder, *U.S.P.*
Compound Pancreatin Powder, *N.F.*
Compound Effervescing Powder, *U.S.P.* (Seidlitz Powder)
Powder of Ipecac and Opium, *U.S.P.* (Dover's Powder)

Pills (*pilula, pilulæ*) are spherical or oval bodies suitable for swallowing. The drug is incorporated with an adhesive substance (glucose, glycerin or acacia) and a diluent (starch). Pills are usually coated with gelatin, sugar, chocolate, keratin or salol to disguise the taste and improve the keeping qualities. When coated with keratin or salol they do not dissolve in the acid secretion of the stomach but do so in the alkaline fluids of the intestine. Nauseous and insoluble drugs are conveniently given in the form of pills.

Pills of Aloe, *U.S.P.*
Pills of Ferrous Carbonate, *U.S.P.* (Blaud's Pills)
Pills of Opium and Camphor, *N.F.*
Vegetable Cathartic Pills, *N.F.*

Tablets (*tabella, tabellæ*) are disk-shaped preparations made from powders usually by compression in a machine. Such tablets are called *compressed tablets.* Tablets may also be made by thoroughly mixing the powder with sugar of milk in a mortar (triturating) and then adding a volatile liquid so as to form a mass which may be molded into tablet form by means of a hand mold. They are then exposed to the air to dry. Such tablets are known as *tablet triturates.* Tablets for hypodermic use are of this type. Well made tablets disintegrate readily when placed in water.

Corrosive Sublimate Tablets, *U.S.P.*
Tablets of Phenolphthalein, *N.F.*
Soda Mint Tablets, *N.F.*
Tablets of Sodium Bicarbonate, *N.F.*

Lozenges (*trochiscus, trochisci*) or troches are flat disk-shaped preparations, usually larger than tablets, containing a cohesive (acacia) so that they will dissolve slowly. They are made to medicate the mouth and the throat and contain an aromatic substance to give them a pleasant taste.

Troches of Tannic Acid, *U.S.P.*
Troches of Ammonium Chloride, *U.S.P.*
Troches of Eucalyptus Gum, *N.F.*
Troches of Elm, *N.F.*

Ointments (*ungentum, ungenta*) are preparations that contain medicinal substances incorporated in a fatty base. They have a butter-like consistency at ordinary temperatures and liquefy at body temperature. Ointments which are to act only on the surface of the skin are usually made with petrolatum as the base. Petrolatum is obtained from petroleum by distilling off the volatile and liquid portions. If penetration into the skin is desired, lard or wool fat may be used as the vehicle.

Ointment of Rose Water, *U.S.P.* (Cold Cream)
Ointment of Zinc Oxide, *U.S.P.*
Ointment of Boric Acid, *U.S.P.*
Camphor Ointment, *N.F.*

Cerates (*ceratum, cerata*) resemble ointments but are made firmer by the addition of beeswax. Due to the presence of wax (*cera*) they are called cerates. The melting point being above body temperature cerates will not run through the dressing but become soft when applied to the skin.

Cantharides Cerate, *U.S.P.*
Camphor Cerate, *N.F.*
Rosin Cerate, *U.S.P.*
Cerate of Lead Subacetate, *N.F.*

Pastes (*pasta, pastæ*) are similar to ointments but of softer consistency. They usually contain antiseptic or astringent agents and are intended for use on the skin and in wounds. The U.S.P. does not include pastes.

Zinc Paste, *N.F.*	Resorcinol Paste, *N.F.*

Plasters (*emplastrum, emplastra*) are medicated adhesive preparations spread in a thin layer on cloth. The base may be India rubber, resin, wax or pitch. Most plasters at the present time are machine made with India rubber as the base. Some plasters are made porous so as to permit the evaporation of sweat.

Adhesive Plaster, *U.S.P.*	Camphorated Brown Plaster, *N.F.*
Belladonna Plaster, *U.S.P.*	Mustard Plaster, *U.S.P.*

Suppositories (*suppositorium, suppositoria*) are conveniently shaped preparations for insertion into some body cavity other than the mouth. The common vehicles used are cocoa butter, glycerinated gelatin and sodium stearate (hard soap). Suppositories melt at body temperature. Rectal suppositories are cone-shaped, urethral suppositories (bougies) are pencil-shaped, and vaginal suppositories are oviform in shape.

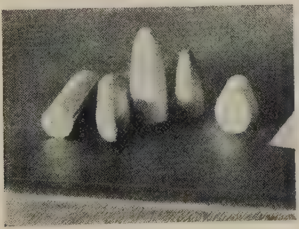

FIG. 16.—Suppositories.

Glycerin Suppositories, *U.S.P.*	Suppositories of Boroglycerin, *N.F.*

EXTRACTIVES

The pharmaceutical preparations that come under this heading are made from crude botanical drugs by extracting their medicinal constituents. *Extraction* is the process of dissolving out the soluble constituents of the crude drug and leaving behind the insoluble matter. This is done either by *maceration* which is the process of steeping the crude drug in a suitable liquid (menstruum) generally alcohol or water, or by *percolation* which is the process by which the medicinal portions of a drug are separated from it by the solvent permeating and descending through it.

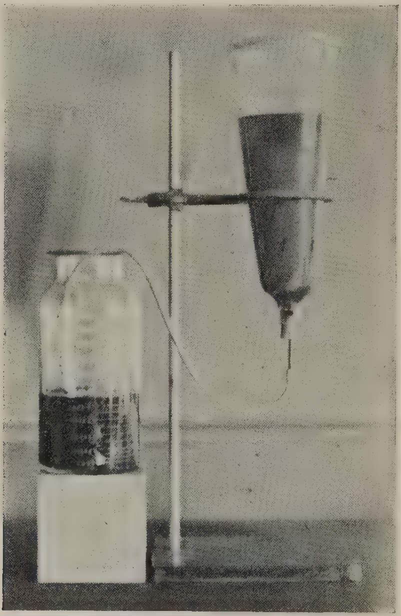

Fig. 17.—Pharmaceutical percolator.

The process of percolation is carried out in a pharmaceutical percolator which consists of a cylindrical vessel (glass or metal) that tapers somewhat toward the bottom. The crude drug is ground up into a powder and placed in the percolator and a suitable menstruum usually alcohol or alcohol diluted with water, is poured over it. The menstruum penetrates to the bottom and gradually dissolves the soluble constituents of the crude drug. After standing several days the valve at the bottom is opened and the liquid is permitted to flow out slowly. This liquid is called the *percolate.* More solvent is added from time to time until all of the medicinal constituents have been extracted. This description applies to the general procedure in making extractives by percolation. It is varied according to the type of preparation made as will be indicated below.

Extracts (*extractum, extracta*) are preparations made by extracting the medicinal principles from crude botanical drugs, by percolation with alcohol or some other solvent. When the extraction is completed the solvent is evaporated and the pasty, semi-solid, or dry residue remaining is the extract. It is usually four or five times as strong as the crude drug itself. The dry extracts are often used in making powders, while the semi-solid extracts may be incorporated in pills, ointments or used in other ways.

Extract of Belladonna, *U.S.P.*
Extract of Cascara Sagrada, *U.S.P.*
Extract of Nux Vomica, *U.S.P.*
Extract of Golden Seal, *N.F.*

Fluidextracts (*fluidextractum, fluidextracta*) are liquid preparations of vegetable drugs, made by extracting the medicinal principles by percolation. The strength is adjusted so that one cubic centimeter of the fluidextract represents one gram of the crude drug. This is done by evaporating a portion of the solvent in a vacuum still. Since one cubic centimeter of a fluidextract contains the medicinal principles that were present in one gram of the crude drug it may be said to have a strength of 100 per cent in relation to the crude drug.

Fluidextract of Belladonna, *U.S.P.*
Fluidextract of Cascara Sagrada, *U.S.P.*
Fluidextract of Golden Seal, *U.S.P.*
Fluidextract of Digitalis, *N.F.*

Tinctures (*tinctura, tincturæ*) are dilute extracts of drugs obtained by macerating or percolating the crude drug with a suitable menstruum containing alcohol. Tinctures of *potent* drugs are prepared so that 100 grams are equivalent to 10 grams of the crude drug, or in other words they are 10 per cent in strength in relation to the crude drug. Tinctures of *non-potent* drugs usually have a strength of 15 to 20 per cent. Some tinctures are made by direct solution. Tincture of iodine is an example of this type of tincture.

Tincture of Belladonna, *U.S.P.*
Tincture of Nux Vomica, *U.S.P.*
Tincture of Digitalis, *U.S.P.*
Tincture of Golden Seal, *N.F.*

Infusions (*infusum, infusa*) are fluid preparations made by steeping a vegetable drug in hot or cold water. Infusions should be freshly made as required for they have poor keeping qualities. Infusions formerly constituted a large class of preparations but at present there is only one infusion in the U.S.P., namely, infusion of digitalis.

Decoctions (*decoctum, decocta*) are fluid preparations made by boiling a vegetable drug with water for fifteen minutes or longer. The active ingredients of many drugs are injured by heat and for this reason decoctions are seldom used. The U.S.P. describes the method of preparation but does not list any decoctions.

AQUEOUS SOLUTIONS

Waters (*aqua, aquæ*) are solutions of volatile drugs in distilled water and are made by the ordinary process of solution. They are sometimes called medicated or aromatic waters. Most of the official waters are weak solutions of aromatic volatile oils in water. They are sometimes used as vehicles for the administration of other remedies.

Peppermint Water, *U.S.P.*
Camphor Water, *U.S.P.*
Rose Water, *U.S.P.*
Witchhazel Water, *N.F.*

Solutions (*liquor, liquores*) according to the U.S.P. are non-volatile drugs dissolved in water. It is only in the pharmacopœia that the term is used in this restricted sense. In the N.F. the term is indiscriminately applied to alcoholic, aqueous and hydro-alcoholic solutions of non-volatile and volatile substances.

Physiological Salt Solution, *U.S.P.*
Lugol's Solution, *U.S.P.*
Fowler's Solution, *U.S.P.*
Dobell's Solution, *N.F.*

Mucilages (*mucilago, mucilagines*) are adhesive liquids made by dissolving certain gums in water. There are two official mucilages, mucilage of acacia made from acacia gum (also known as gum arabic), and mucilage of tragacanth made from gum tragacanth. Mucilages are used in making pills, lozenges, and serve as suspending agents in emulsions.

Syrups (*syrupus, syrupi*) are concentrated solutions of sugar containing a medicinal substance. The solvent is usually water but sometimes glycerin or alcohol are used in addition to water. Syrups have good keeping qualities because of the large percentage of sugar present.

Syrup of Pine Tar, *U.S.P.*
Syrup of Squill, *U.S.P.*
Syrup of Wild Cherry, *U.S.P.*
Syrup of Licorice, *N.F.*

ALCOHOLIC SOLUTIONS

Spirits (*spiritus, spiriti*) are alcoholic solutions of volatile substances. Those made from volatile oils are sometimes called essences.

Aromatic Spirit of Ammonia, *U.S.P.*
Spirit of Peppermint, *U.S.P.*
Spirit of Camphor, *U.S.P.*
Spirit of Bitter Almond, *N.F.*

Elixirs (*elixir, elixiria*) are hydro-alcoholic solutions of medicinal substances, pleasantly flavored and sweetened with sugar.

Elixir of Licorice, *U.S.P.*
Elixir of Iron, Quinine and Strychnine, *N.F.*
Elixir of Beef and Iron, *N.F.*
Elixir of Pepsin, *N.F.*

SUSPENSIONS

Mixtures (*mistura, misturæ*) are aqueous liquid preparations that contain an insoluble powdered drug in suspension. A viscid agent such as glycerin is usually used to hold the drug in suspension. Mixtures make possible the administration of insoluble substances in liquid form. The label "shake before using" suggests that the preparation is a mixture.

Chalk Mixture, *U.S.P.*
Milk of Magnesia, *U.S.P.*
Brown Mixture, *U.S.P.*
Compound Mixture of Rhubarb, *N.F.*

Emulsions (*emulsum, emulsa*) are fixed oils (sometimes volatile oils or resins) suspended in the form of minute globules in water. The resulting substance is an opaque milk-like liquid. To keep the oil in suspension muscilage of acacia is usually added. Emulsions are usually sweetened and flavored with volatile oils.

Emulsion of Cod Liver Oil, *U.S.P.*
Emulsion of Asafetida, *U.S.P.*
Emulsion of Petrolatum, *N.F.*
Emulsion of Oil of Turpentine, *U.S.P.*

MISCELLANEOUS PREPARATIONS

Liniments (*linimentum, linimenta*) consist of medicinal substances dissolved in fixed oils, alcohol or soft soap. They are intended for external use only. The name comes from the Latin *linere*, which means "to smear." They are usually applied with friction and generally contain a volatile oil or other irritant. The friction and massage with which liniments are applied aid the action of the drug.

Camphorated Oil, *U.S.P.*
Chloroform Liniment, *U.S.P.*
Camphorated Soap Liniment, *N.F.*
Belladonna Liniment, *N.F.*

Glycerites (*glyceritum, glycerita*) are solutions of medicinal substances in glycerin. They are useful preparations since they can be diluted with alcohol or water without precipitation.

Glycerite of Tannic Acid, *U.S.P*
Glycerite of Tar, *N.F.*
Glycerite of Phenol, *U.S.P.*
Glycerite of Boroglycerin, *U.S.P.*

Collodions (*collodium, collodia*) are medicated liquid preparations containing soluble gun-cotton (pyroxylin) in a mixture of ether and alcohol. They are intended for application to the skin. The ether and alcohol evaporate leaving a film on the surface which serves as a protection and also holds the medicine in contact with the skin. Pyroxylin is a mixture of several nitrates of cellulose and is made by treating purified cotton with a mixture of sulphuric and nitric acids.

Collodion, *U. S. P.*
Styptic Collodion, *N.F.*
Flexible Collodion, *U.S.P.*
Compound Salicylic Collodion, *N.F.*

Capsules (*capsula, capsulæ*) are gelatin containers for enclosing medicines. There are two varieties, hard and soft. The *soft capsules* are spherical in shape and are kept soft by glycerin. The *hard capsules* are cylindrical shells, made in two parts, the body which is to be filled and a well fitting cover. Hard capsules are very useful for administering powders. Quinine sulphate and the coal tar analgesics are often administered in hard capsules. Soft capsules may be used for oily liquids. Capsules are not listed in the U.S.P. or N.F.

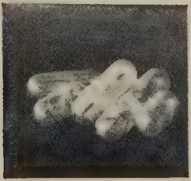
Fig. 18.—Hard capsules.

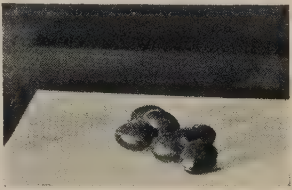
Fig. 19.—Soft capsules.

Ampules (*ampula, ampulæ*) are small flask-shaped glass containers, holding a sufficient quantity of a medicinal liquid or solid, in a sterile condition, for a single administration. They are sealed by fusing the glass at the tip with heat and are intended for hypodermic medication. The name comes from the Latin, *ampulla* meaning flask. They are not recognized in the U.S.P.

Ampules of Emetine Hydrochloride, *N.F.*
Ampules of Sodium Cacodylate, *N.F.*
Ampules of Iodine, *N.F.*
Ampules of Caffeine Sodio-Benzoate, *N.F.*

Questions for Class Discussion

1. What are pharmaceutical preparations?
2. Define the term pharmacy.
3. What is a powder in pharmacy?
4. How do pills differ from tablets?
5. What is a lozenge?
6. What are ointments? How do they differ from cerates and pastes?
7. Define the term plaster as used in pharmacy.
8. What are suppositories? Name the bases used in making them.
9. Describe the process of percolation used in extracting the medicinal constituents of plant drugs.
10. What are extracts? How do they compare in strength with the crude drug?
11. What are fluidextracts? What is their strength?
12. How do tinctures differ from fluidextracts? Give the strength of potent and non-potent tinctures.
13. Define (a) infusions, (b) decoctions.
14. What are the preparations known as waters?
15. What are pharmacopœial solutions?
16. Define the term muscilage as used in pharmacy.
17. What are syrups?
18. How do spirits differ from elixirs?
19. Compare mixtures with emulsions.
20. Define (a) liniments, (b) glycerites.
21. What are collodions and how are they used?
22. What is an ampule?

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CHAPTER V

THERAPEUTIC CONSTITUENTS OF PLANT DRUGS

General Considerations.
Alkaloids.
Organic Acids.
Glucosides.
Fixed Oils.
Volatile Oils.
Tannins.
Resins and Balsams.

GENERAL CONSIDERATIONS

The therapeutic action of a plant drug is due to one or more of its chemical constituents. Besides the desirable active constituents a vegetable drug may contain other chemical substances which either play no part in the therapeutic action or exert undesirable effects. The chief classes of active constituents are listed above.

In many cases the medicinal constituents can be readily obtained from the plant, this is true of the volatile and fixed oils. In other cases they are intimately associated with other substances so that their isolation cannot be accomplished as easily. The active constituents of many of the medicinal plants have not yet been isolated. More reliable results can usually be obtained if the active constituent is administered in pure form because the dose can be more accurately controlled and undesirable side actions are not likely to occur. It is often possible to administer the active principle hypodermically.

ALKALOIDS

The term *alkaloid* means "alkali-like." The alkaloids are active principles found in the seeds, leaves, bark, and other parts of plants. In most cases they exist in combination with natural acids, such as tannic, citric, and malic. The alkaloids include many of our most powerful drugs. Chemically the alkaloid molecule is of complex structure containing nitrogen, carbon, hydrogen and usually oxygen atoms. Alkaloids have an alkaline reaction in that they turn red litmus blue and form salts when combined with acids. They are either insoluble or very slightly soluble in water but their salts are usually freely soluble. They are very potent physiologically even in small doses and some are very poisonous. The salts of the alkaloids have the same therapeutic action as the uncombined alkaloids and due to the fact that they are soluble in water are more convenient to use in medicine. Many of the alkaloids are precipitated by tannic acid.

TABLE OF IMPORTANT ALKALOIDS

Name	Source	Medicinal preparation
Morphine..........	Opium	Morphine Sulphate
Codeine...........	Opium	Codeine Sulphate
Cocaine...........	Coca Leaves	Cocaine Hydrochloride
Quinine...........	Cinchona Bark	Quinine Hydrochloride
Strychnine.........	Nux Vomica Seeds	Strychnine Nitrate
Atropine..........	Belladonna Leaves	Atropine Sulphate
Caffeine...........	Coffee, Tea, etc.	Caffeine Sodio-Benzoate
Emetine...........	Ipecac Root	Emetine Hydrochloride
Pilocarpine........	Jaborandi Leaves	Pilocarpine Hydrochloride
Apomorphine......	Morphine Derivative	Apomorphine Hydrochloride
Procaine...........	Synthetic	Procaine Hydrochloride

ORGANIC ACIDS

The sour taste of certain fruits is due to organic acids or their salts. Organic acids differ from inorganic acids in that they are but slightly ionized in aqueous solutions. Most organic acids have a mild effect on the body but some, such as glacial acetic acid (concentrated acetic acid) have a caustic action. Organic acids and their salts are used in therapeutics. Those of importance are citric, tartaric, acetic, and lactic acid.

Citric acid occurs in the juice of lemons, limes, oranges, grapefruit, and other acid fruits. Tartaric acid is found in many fruits, chiefly in grapes in the free state or in the form of its salts. Acetic acid occurs in vinegar. Glacial acetic acid contains 99 per cent of acetic acid. Lactic acid may be obtained from certain plants and also from sour milk.

Table of Organic Acids and Their Salts

- Citric Acid
  - Citrate of Magnesia U.S.P.
  - Potassium Citrate U.S.P.
  - Sodium Citrate U.S.P.
- Acetic Acid
  - Ammonium Acetate U.S.P.
  - Potassium Acetate U.S.P.
  - Lead Acetate U.S.P.
- Tartaric Acid
  - Antimony & Potassium Tartrate U.S.P.
  - Potassium Bitartrate U.S.P.
  - Potassium & Sodium Tartrate U.S.P.
- Lactic Acid
  - Calcium Lactate U.S.P.
  - Iron Lactate N.F.
  - Silver Lactate N.N.R.

GLUCOSIDES

Glucosides are complex compounds that are chemically neutral. The only characteristic they have in common is that upon decomposition they yield glucose or some other form of sugar. This characteristic has no bearing on their therapeutic actions.

They are readily soluble in water. Digitalis leaves contain a number of glucosides of similar action, namely, *digitoxin*, *digitalein*, and *digitalin*. These glucosides have a characteristic action upon the heart-muscle and are used in the treatment of cardiac affections. Strophanthus seeds contain a glucoside known as *strophantin* which is also a cardiac stimulant.

FIG. 20.—Peppermint oil distillery. (From The Story of Drugs by H. C. Fuller, Century Co., Publishers.)

FIXED OILS

Fixed oils are compounds of fatty acids and glycerin. They are greasy, insoluble in water and in alcohol (except croton oil and castor oil). They combine with alkalies to form soap and glycerin. They cannot be distilled without decomposition and leave a stain on paper or cloth which will not disappear on warming. Examples of fixed oils are, olive oil (from ripe olives) used as a laxative and emollient; cottonseed oil (from seeds of cotton plant) used as a demulcent and laxative; and castor oil (from seeds of castor plant) used as a purgative.

VOLATILE OILS

Volatile oils are widely distributed in the plant kingdom and are obtained by the process of distillation or expression. They are odorous, volatile, non-greasy liquids and do not contain glycerin. Their most noticeable characteristic is their strong odor which is usually pleasing. They are soluble in alcohol and to a slight extent in water and have various therapeutic uses as suggested by the table below. Menthol, thymol, eucalyptol and camphor are obtained from volatile oils.

Table of Important Volatile Oils

Name	Source	Therapeutic properties
Oil of Peppermint	Peppermint Herb	Carminative and Flavor
Oil of Eucalyptus	Leaves of Eucalyptus Tree	Antiseptic in Nose and Throat
Oil of Juniper....	Fruit of Juniperus	Stimulant and Diuretic
Oil of Rosemary	Flowering Tops of Rosmarinus	Carminative
Sandalwood Oil..	Heart-Wood of Santalum	Antiseptic in Urethritis
Oil of Sassafras.	Roots of Sassafras	Stimulant and Carminative
Oil of Cinnamon.	Leaves and Twigs of Cinnamonum	Carminative and Flavor
Oil of Clove......	Flower Buds of Caryophyllus	Anodyne in Toothache
Oil of Orange....	Orange Peel	Flavoring Agent in Elixirs
Oil of Thyme....	Flowering Tops of Thymus	Antiseptic

TANNINS

In the roots, wood, and bark of many trees and shrubs substances known as tannins are found. They are also present in the nut-galls on oak trees. Tannins are astringent principles readily soluble in water. They precipitate proteids, alkaloids and certain salts of the heavy metals. Tannins are valuable antidotes in poisoning caused by alkaloids and metallic salts. Tannic acid is an official tannin in common use.

RESINS AND BALSAMS

Resins are plant exudates obtained by making incisions in the stems of plants. They are solid, uncrystallizable and insoluble in water but soluble in alcohol or ether. Rosin is an example of a resin. Resins sometimes occur in combination with volatile oils and are then called *oleo-resins.* Resins also occur combined with balsamic acids, such as benzoic or cinnamic acids, and are then known as *balsams.* These acids are aromatic and give balsams their delightful odors. Balsams are used to promote healing in wounds and inflamed mucous membranes.

TABLE OF RESINOUS DRUGS

Name	Source	Nature	Therapeutic use
Podophyllum...	Mandrake Root	Resin	Cathartic
Aspidium......	Male Fern	Oleoresin	Expell Tapeworm
Ginger.........	Jamaica Ginger	Oleoresin	Stimulant and Flavor
Balsam of Peru	Toluifera Pereirae	Balsam	Stimulant and Antiseptic
Balsam of Tolu	Toluifera Balsamum	Balsam	Stimulant and Expectorant

Questions for Class Discussion

1. What is meant by the active principle of a drug?
2. Why is it desirable to use the pure active principle in therapeutics?
3. State the chief characteristics of alkaloids.
4. In what form are alkaloids used therapeutically?
5. Name the alkaloids obtained from opium, coca leaves, cinchona bark, nux vomica seeds, and belladonna leaves.
6. What are organic acids? Give examples.
7. In what form are they usually employed?
8. Define the term glucoside? Give examples.
9. How do fixed oils differ from volatile oils?
10. Name three fixed oils and five volatile oils used in therapeutics.
11. Give the sources and characteristics of tannins.
12. Define resins, oleoresins, balsams and give examples.

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CHAPTER VI

ANIMAL DRUGS AND BIOLOGICAL PRODUCTS

GLANDULAR PRODUCTS.
  Digestive Glands.
    Pepsin. Pancreatin.
  Endocrine Glands.
    Thyroid. Pituitary Extract.
    Epinephrine. Insulin.

MISCELLANEOUS ANIMAL DRUGS.
BIOLOGICAL PRODUCTS.
  Antisera. Toxins.
  Vaccines. Allergic Preparations.

The modern materia medica contains various products from animal substances and also preparations known as "biologicals." Some of these preparations contain enzymes obtained from the digestive glands while others contain the active agents present in the secretions of the endocrine glands.

GLANDULAR PRODUCTS

A gland is a group of cells adapted for the production of a fluid secretion. Glands may be simple and very small like the mucous glands, or large and complex like the liver. The body contains two kinds of glands, (1) those that have ducts that open into some other organ, and (2) those without ducts. The latter are called ductless or endocrine glands. The digestive glands are of the former type. The use of glandular products in therapeutics is spoken of as *organotherapy*.

Digestive Glands.—The digestion of food is accomplished by *enzymes* which are catalytic agents of colloidal nature but of unknown composition. Enzymes accelerate chemical reactions without being themselves changed. A small quantity of an enzyme can produce changes in a large quantity of material. Enzymes have not yet been isolated in pure form, although preparations containing them in high concentration can be obtained.

The gastric glands in the walls of the stomach secrete a fluid called gastric juice which contains a protein digesting enzyme (protease) known as *pepsin.* For therapeutic purposes pepsin is obtained from the glandular layer of the fresh stomachs of hogs, sheep and calves.

The pancreas is another digestive gland which pours its secretions into the duodenum. It contains three enzymes, namely, trypsin (a protease) which digests proteids, amylopsin (an amylase) which converts starch into dextrose, and steapsin (a lipase) which changes fats into fatty acids and glycerin. The therapeutic preparation obtained from the pancreas is known as *pancreatin* and contains the three enzymes named above but usually the lipase is not present in the active state. Both pepsin and pancreatin are official preparations.

Endocrine Glands.—These glands give rise to internal secretions that pass directly into the blood stream and contribute, each its characteristic part, in maintaining the normal health of the body. Some have a general action in that they affect the metabolism of all of the cells while others affect only certain types of cells. The active substances in these secretions are known as *hormones.* This name comes from the Greek and means to arouse or stimulate to activity.

In the past decade the endocrine glands and their secretions have received intensive study. Our present knowledge of these glands and their functions is, however, still rather elementary. There are several whose functions are more or less understood. These are the thyroid gland, pituitary body, suprarenal glands, and the insular part of the pancreas (Islands of Langerhans). Other organs producing an internal secretion about which less is known are the parathyroid glands, gonads, thymus gland, pineal gland, spleen, and mammary glands.

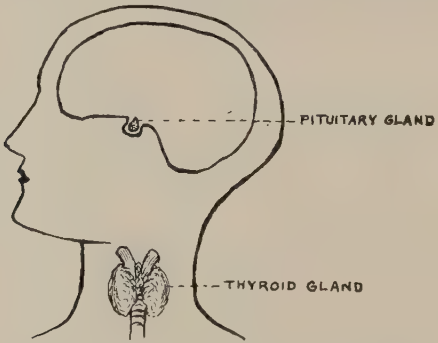

FIG. 21.—Pituitary and thyroid glands.

Preparations from various glands are used therapeutically to produce certain definite effects in the body in the same manner that other medicines are used, and also to make up a deficiency in endocrine secretions in the body. The dried, powdered glands or liquid extracts of the glands are used. In some cases, however, the active principles have been isolated and also made synthetically.

The **thyroid gland** lies in the neck in front of and at the sides of the trachea. It consists of two lateral lobes connected by a narrow strip called the isthmus. It secretes a colloidal fluid which contains iodine. The secretion appears to have a catalytic effect on cell chemistry and increases the rate at which the body uses up food material. It is neccessary for normal growth and development. A deficiency of this secretion in infancy causes cretinism (stunted physical and mental development), and in adults myxoedema and simple goiter.

The active principle has been isolated and is known as *thyroxin.* It is a white crystalline compound and contains 65 per cent of iodine. It can also be prepared synthetically. It may be administered by mouth or hypodermically. Therapeutically thryoid preparations are useful as a substitute for the normal gland secretion in cases where this is wanting or deficient as in cretinism, myxoedema, and certain types of goiter.

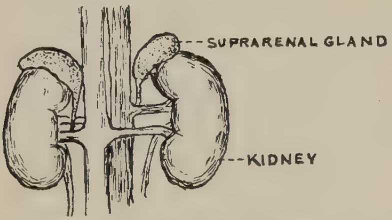

FIG. 22.—Suprarenal glands.

The **suprarenal glands** are situated above the kidneys. Each gland consists of two parts, the cortex and medulla. It is only the medulla that has medicinal value. The active principle is *epinephrine* which has been isolated from the glands and can also be made synthetically. When epinephrine is injected intravenously the force of the hearts contraction is strengthened and the blood pressure is increased due to the contraction of the blood vessels. It may be used to check hemorrhage from mucous membranes to which it can be directly applied, as in the nose and throat.

The **pituitary body** is situated in a cup-shaped depression in the sphenoid bone at the base of the brain and consists of two lobes, the anterior and posterior (hypophysis). Pituitrin, an extract from the posterior lobe, is used in therapeutics. It causes contraction of the unstriped muscle fibers of the uterus and intestines. It is used to stimulate contraction of the uterus in the second stage of labor. Following surgical operations it is used to stimulate peristalsis and thus facilitate the expulsion of gas from the alimentary tract. Recently two active principles, one a pressor (blood-pressure raising) and the other an oxytocic (causing uterine contractions), have been isolated from the posterior lobe.

The **islands of Langerhans** appear as a small collection of cells in the pancreas from which they are separated by a delicate capsule of connective tissue. These cells secrete into the blood a hormone which maintains the body's power to metabolize carbohydrates and limits the amount of sugar in the blood, keeping it from rising above normal. The normal sugar content of the blood is about 0.1 per cent. If this hormone is wanting or deficient in amount the sugar concentration of the blood rises above 0.1 per cent and an overflow of sugar into the urine occurs. This happens in diabetes.

The hormone of the islands of Langerhans is present in *insulin* which is a purified extract of this gland. When given to a diabetic patient, insulin lowers the amount of sugar in the blood and temporarily relieves the sufferer. If an overdose of insulin is administered the sugar concentration of the blood falls below normal and collapse and death quickly follow unless corrective treatment is promptly applied.

MISCELLANEOUS ANIMAL DRUGS

Oxgall is the fresh bile of animals of the ox family. It contains sodium salts of glycocholic and taurocholic acids. These salts are spoken of as bile salts. Powdered extract of oxgall is an official preparation containing bile salts. It is used therapeutically when there appears to be a deficiency of bile in the intestines.

Cod liver oil is obtained from the fresh livers of cod fish. It is used to provide the body with vitamins A and D, and as a nutrient in wasting diseases. Pure cod liver oil and emulsion of cod liver oil are official preparations.

Cantharides consists of dried beetles (Spanish flies) ground into a powder. It contains cantharidin which causes blistering when applied to the skin. It is official in the form of a cerate and plaster.

Certain animal fats, such as lard, wool-fat, beeswax, and spermaceti (from head of sperm whale), are employed to give consistency to ointments and cerates. Liver and liver extracts have come into use in the treatment of pernicious anemia and other forms of anemia.

BIOLOGICAL PREPARATIONS

This term applies to antisera, vaccines and various specific and non-specific proteins of plant or animal origin. *Antiserum* is obtained by inoculating a healthy animal (usually a horse) with gradually increasing doses of bacterial toxins or the bacteria themselves. After several months, blood is withdrawn from the jugular vein of the horse and permitted to clot. The serum is separated from the clot and is then known as antiserum. When the animal is inoculated with a bacterial toxin the resulting antiserum is called antitoxin. Diphtheria antitoxin, which was introduced in 1893, was the first antiserum that came into use.

The chief value of antisera lies in their curative properties. They contain antibodies which counteract the toxic substances produced by the bacteria, or the bacteria themselves.

TABLE OF IMPORTANT ANTISERA

Diphtheria Antitoxin	Anti-Pneumococcus Serum
Tetanus Antitoxin	Anti-Meningococcus Serum
Scarlet Fever Antitoxin	Anti-Streptococcus Serum

Toxins are produced by certain bacteria and may be obtained by growing the bacteria in suitable liquid culture media. Toxins may be used to prevent the development of disease. They are of value in the prevention of scarlet fever and diphtheria. In the case of diphtheria the toxin is mixed with antitoxin and the mixture is known as *toxin-antitoxin.*

Vaccines are suspensions of microorganisms in glycerin or physiological salt solution. In some vaccines the microorganisms have been killed (usually by heat) while in others they are alive but in attenuated form. They are used chiefly to prevent disease. The term *bacterin* is sometimes applied to a vaccine that consists of killed bacteria.

Certain diseases, such as hay fever and certain cases of asthma, are caused by foreign proteins. Some people are hypersensitive to certain proteins and develop symptoms when they come in contact with them. This condition of sensitiveness is known as *allergy.* The hypersensitiveness may be toward pollen, certain foods, hair, feathers or other substances containing proteins. The treatment consists of hypodermic injections of an extract of the offending substance. Extracts used in the treatment of cases of allergy are known as *allergic preparations.*

TABLE OF ALLERGIC PREPARATIONS

Pollen Extracts—about 90 different kinds
Food Protein Extracts—about 60 different kinds
Hair Extracts—about 8 different kinds
Feather Extracts—about 3 different kinds
Miscellaneous—Cottonseed, Orris Root, Rice Powder, Silk, Glue, etc.

In some chronic infections so-called *non-specific protein* agents such as sterilized milk or peptone are used with success. These agents seem to stimulate the defensive forces of the body, either by a leukocytosis or mobilization of chemical defensive substances.

QUESTIONS FOR CLASS DISCUSSION

1. What is meant by organotherapy?
2. What are enzymes?
3. Which digestive enzymes are used in medicine?
4. What is pancreatin?
5. What are endocrine glands? hormones?

6. Name the active physiological principle of the thyroid secretion. What is its therapeutic use?

7. What is epinephrine?

8. Of what therapeutic value are (a) epinephrine (b) pituitary extract?

9. Give the sources of (a) oxgall, (b) cod liver oil, (c) cantharides, (d) spermaceti.

10. What is meant by the term biological preparations as used in therapeutics?

11. What is an antiserum? how prepared?

12. Compare the terms antiserum and antitoxin.

13. What effects do antisera produce in the body?

14. What are toxins? How are they used therapeutically?

15. Define: (a) vaccine, (b) bacterin.

16. What are allergic preparations?

17. Name some (a) allergic preparations, (b) nonspecific protein preparations.

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CHAPTER VII

ARITHMETIC REVIEW

Arabic and Roman Numerals.
Common Fractions.
Decimal Fractions.
Converting Common into Decimal Fractions and Vice Versa.
Percentage.
Ratio.

In the preparation of solutions and doses it is necessary to make exact calculations. The student, therefore, must have a working knowledge of the fundamental operations in arithmetic. This review is devoted chiefly to common fractions, decimal fractions, percentage, and ratio. The student should acquire a thorough understanding of each principle presented in this chapter. Facility at figures is an asset to anyone.

ARABIC AND ROMAN NUMERALS

Two systems of representing numbers are in use, namely, Arabic and Roman. The Arabic system uses the symbols 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. In the Roman system certain capital letters namely I, V, X, L, C, D, M are used.

I = 1
V = 5
X = 10
L = 50
C = 100
D = 500
M = 1000

When I precedes V or X, or X precedes L or C the value is determined by subtracting the lower from the higher (IV = 4, IX = 9, XL = 40, XC = 90). When a numeral of lower value follows one of higher value, the value is determined by adding the numerals (VI = 6, XII = 12, LXV = 65, CXX = 120). Roman numerals are often used by physicians in writing prescriptions.

COMMON FRACTIONS

A fraction is one or more of the equal parts of a unit. In a common fraction there are two numbers, one above and one below a horizontal line. These two numbers are called the *terms* of the fraction. The term below the line is the *denominator* while the term above the line is the *numerator.*

A fraction may also be regarded as an expression of division. The numerator is the dividend, the denominator the divisor, and the fraction itself the quotient.

A fraction in which the numerator is less than the denominator is a *proper fraction.* If the numerator exceeds the denominator the fraction is an *improper* one. A *complex fraction* is one which has a fraction for one or both of its terms, as for example $\frac{\frac{3}{4}}{2}$ or $\frac{\frac{2}{5}}{\frac{2}{7}}$. A number which is composed of a whole number and a fraction is called a *mixed number* ($4\frac{1}{2}$, $6\frac{3}{4}$).

A fraction may be reduced to its lowest terms by dividing both terms of the fraction by the same number ($\frac{6}{9} = \frac{2}{3}$). This does not change the value of the fraction.

ADDITION AND SUBTRACTION OF FRACTIONS

When common fractions with different denominators are to be added, the fractions must first be changed so that each one will have the same denominator. The *least common denominator* (L.C.D.) of two or more fractions is the least number which contains the denominator of each of the fractions a whole number of times. To find the least common denominator of a number of fractions it is only necessary to find the least common multiple (L.C.M.) of the denominators of the fractions.

In order to add $\frac{1}{4}$, $\frac{1}{2}$, $\frac{2}{3}$, and $\frac{5}{6}$ one must first find the L.C.M. of 4, 2, 3, and 6. This may be done as follows:

$$\begin{array}{r|l} 2 & 4,\ 2,\ 3,\ 6 \\ \cline{2-2} 3 & 2\ \ 1\ \ 3\ \ 3 \\ \cline{2-2} \multicolumn{1}{r}{} & 2\ \ 1\ \ 1\ \ 1 \end{array}$$

The denominators are placed in line and divided by a number which will divide two or more of them without a remainder. This is continued until all have been so divided that can be. Next multiply together all the divisors and remaining undivided numbers, $2 \times 3 \times 2 \times 1 \times 1 \times 1 = 12$. Twelve in this case is the L.C.M. because it is the smallest number which will contain 4, 2, 3, and 6 without a remainder. The next step is to convert $\frac{1}{4}$, $\frac{1}{2}$, $\frac{2}{3}$, and $\frac{5}{6}$ to 12*ths*. This is done by dividing 12 by the denominator of the fraction, multiplying the quotient by the numerator, and placing the result over the common denominator. The numerators are then added and the sum is written over the denominator.

In subtracting one fraction from another, both fractions must have the same denominator, just as in the addition of fractions. The numerator of one is then subtracted from the numerator of the other and the difference is written over the denominator.

Multiplication of Fractions

In the multiplication of fractions the numerators are multiplied together for a new numerator and the denominators are multiplied together for a new denominator. The word "of" written between two fractions or between a fraction and a whole or mixed number indicates that they are to be multiplied.

When a number of fractions are to be multiplied together, as $\frac{1}{5} \times \frac{1}{2} \times \frac{3}{4} \times \frac{2}{3}$ a short method known as *cancellation* may be employed. Three in the denominator cancels 3 in the numerator, and 2 in the denominator cancels 2 in the numerator. This may be carried out as follows:

$$\frac{1}{5} \times \frac{1}{\cancel{2}} \times \frac{\cancel{3}}{4} \times \frac{\cancel{2}}{\cancel{3}} = \frac{1}{20}$$

In the multiplication of a fraction by a whole number the numerator of the fraction is multiplied by the whole number and the denominator of the fraction becomes the denominator of the product. In multiplying $\frac{3}{8}$ by 3 the $\frac{3}{8}$ is taken 3 times, that is $\frac{3}{8} + \frac{3}{8} + \frac{3}{8} = \frac{9}{8}$.

Division of Fractions

In the division of common fractions, the fraction which is the divisor is inverted and it is then used as a multiplier.

$$\frac{4}{5} \div \frac{3}{4} = \frac{4}{5} \times \frac{4}{3} = \frac{16}{15} = 1\tfrac{1}{15}.$$

Exercises in Common Fractions

1. Reduce the following fractions to their lowest terms:

$\frac{15}{36}$ $\frac{55}{135}$ $\frac{36}{96}$ $\frac{81}{144}$ $\frac{120}{144}$
$\frac{108}{132}$ $\frac{144}{128}$ $\frac{72}{108}$ $\frac{175}{225}$ $\frac{65}{169}$

2. Write the following improper fractions as mixed numbers:

$\frac{15}{4}$ $\frac{62}{9}$ $\frac{85}{11}$ $\frac{78}{14}$ $\frac{73}{12}$
$\frac{220}{16}$ $\frac{250}{9}$ $\frac{785}{41}$ $\frac{960}{66}$ $\frac{8475}{29}$

3. Change the following mixed numbers to fractions:

$4\frac{2}{8}$, $6\frac{4}{7}$, $14\frac{2}{5}$, $9\frac{1}{11}$, $9\frac{5}{7}$, $13\frac{3}{4}$, $8\frac{7}{8}$, $3\frac{4}{5}$.

4. Simplify:

(a) $\dfrac{7\frac{1}{4}}{25}$

(b) $\dfrac{9}{4\frac{1}{2}}$

(c) $\dfrac{\frac{1}{2}}{\frac{1}{3}}$

(d) $\dfrac{2\frac{1}{2}}{4\frac{1}{5}}$

(e) $\dfrac{4\frac{1}{11}}{7\frac{7}{8}}$

(f) $\dfrac{\frac{1}{2}}{100}$

5. Find the value of:

(a) $\frac{2}{3} + \frac{4}{3}$
(b) $\frac{1}{2} + \frac{1}{4}$
(c) $\frac{3}{4} + \frac{2}{8}$
(d) $\frac{6}{7} + \frac{2}{9}$
(e) $4\frac{1}{2} + 1\frac{2}{3}$
(f) $11\frac{3}{5} + 3\frac{5}{8}$
(g) $\frac{1}{2} + \frac{1}{5} + \frac{1}{3}$
(h) $\frac{5}{7} + \frac{1}{2} + \frac{9}{14}$
(i) $\frac{3}{4} + \frac{7}{8} + \frac{3}{6} + \frac{3}{8}$

6. Find the value of:

(a) $\frac{8}{9} - \frac{3}{9}$
(b) $\frac{7}{8} - \frac{3}{4}$
(c) $\frac{11}{12} - \frac{3}{6}$
(d) $\frac{18}{25} - \frac{3}{5}$
(e) $4\frac{5}{8} - 1\frac{1}{2}$
(f) $15\frac{5}{6} - 9\frac{7}{12}$

7. Find the value of:

(a) $\frac{1}{5}$ of $\frac{1}{6}$
(b) $\frac{1}{3} \times \frac{6}{7}$
(c) $\frac{1}{8}$ of $\frac{24}{25}$
(d) $\frac{3}{5}$ of $\frac{4}{7}$
(e) $\frac{3}{10}$ of $\frac{9}{11}$
(f) $\frac{11}{20} \times 36$
(g) $\frac{7}{9} \times 27$
(h) $\frac{1}{8}$ of $5\frac{1}{3}$
(i) $\frac{3}{5} \times \frac{5}{16} \times 2\frac{2}{3}$

8. Find the value of the following by the method of cancellation:

(a) $\frac{42}{100} \times \frac{63}{91} \times \frac{39}{60}$
b) $\frac{32}{80} \times \frac{57}{48} \times \frac{45}{60}$

9. Find the value of:

(a) $\frac{1}{2} \div \frac{1}{2}$
(b) $\frac{1}{2} \div \frac{3}{4}$
(c) $\frac{1}{3} \div \frac{1}{4}$
(d) $2\frac{1}{4} \div \frac{8}{9}$
(e) $3\frac{1}{7} \div 2\frac{1}{5}$
(f) $\frac{9}{10} \div 4$
(g) $6 \div \frac{3}{5}$
(h) $5\frac{13}{25} \div 46$
(i) $\frac{1}{2}$ of $\frac{4}{7} \div \frac{2}{3}$

DECIMAL FRACTIONS

Decimal fractions, also called decimals, are fractions whose denominators are 10 or some multiple of 10, that is 100, 1000, 10,000, etc. Instead of writing the denominator a decimal point is used. All figures to the left of this point represent whole numbers, while all to the right, fractions. The value of each digit depends upon the place it occupies. The first decimal place expresses tenths, the second hundredths, the third thousandths, etc.

Addition and Subtraction of Decimals

In the addition and subtraction of decimals, units are placed under units, tens under tens, tenths under tenths, hundredths under hundredths, etc. This brings the decimal points in a perpendicular row. The addition or subtraction is carried out as in whole numbers. The decimal point in the answer is placed directly under the decimal points in the numbers to be added or subtracted.

Multiplication of Decimals

The only difference in the multiplication of whole numbers and decimals is that in the latter the decimal point has to be placed. In multiplying decimals point off as many places in the product as there are decimal places in both terms of the problem.

Division of Decimals

In the division of decimals there must be as many decimal places in the dividend as there are in the divisor. If necessary supply the required number by adding zeros to the dividend. In the quotient point off as many decimal places as those in the dividend exceed those in the divisor.

Examples:

	Divisor	Dividend	Quotient
1. 5.5 ÷ .5	.5)	5.5	(11
2. 5 ÷ .5	.5)	5.0	(10
3. 5 ÷ .05	.05)	5.00	(100
4. 5 ÷ .005	.005)	5.000	(1000
5. 5.5 ÷ 5	5)	5.5	(1.1

Exercises in Decimals

1. Write the following in decimal form: $\frac{6}{100}$, $\frac{14}{1000}$, $\frac{5}{1000}$, $\frac{805}{10000}$, $\frac{327}{100000}$, $18\frac{6}{100}$, $365\frac{7}{1000}$.

2. Find the value of:

   (a) $.9 + .6 + .45 + .38 + .835 + .418$
   (b) $8.3 + 18.7 + 365.4 + 3.8 + 54.6$
   (c) $135.78 + .752 + .008 + .070809$

3. Find the value of:

   (a) $48.4 - 3.87216$
   (b) $1001 - 5.846$
   (c) $.90683 - .89652$
   (d) $.10205 - .010302$

4. Find the value of:

   (a) $.436 \times .02$
   (b) $.274 \times 9.6$
   (c) 9.43×5.2
   (d) $3.0026 \times .0021$

5. Divide:

   (a) 24 by .05
   (b) .05 by 24
   (c) 87.5 by 35
   (d) 15.812 by 23.6
   (e) 8.547 by .077
   (f) 2.001 by 1.002
   (g) 65 by 5000
   (h) .69800 by 2.3
   (i) .461082 by 12.23

CONVERTING COMMON INTO DECIMAL FRACTIONS AND VICE VERSA

To convert a common fraction into a decimal the numerator of the fraction is divided by the denominator. Thus $\frac{3}{4} = 3 \div 4 = .75$.

A decimal fraction may be expressed as a common fraction by dropping the decimal point and writing the denominator. Thus $.75 = \frac{75}{100} = \frac{3}{4}$.

Exercises

1. Convert into decimals:

   (a) $\frac{1}{2}, \frac{1}{4}, \frac{3}{4}, \frac{1}{5}, \frac{2}{5}, \frac{4}{5}, \frac{1}{8}, \frac{7}{8}$.
   (b) $\frac{1}{20}, \frac{7}{20}, \frac{1}{25}, \frac{3}{25}, \frac{6}{30}, \frac{10}{30}, \frac{9}{32}, \frac{16}{32}$.
   (c) $\frac{2}{3}, \frac{5}{6}, \frac{7}{11}, \frac{8}{13}, \frac{7}{15}, \frac{11}{18}, \frac{9}{14}, \frac{61}{121}$.

2. Express as common fractions in their lowest terms:

   (a) .2, .3, .5, .6, .64.
   (b) .05, .025, .001, .065, .344.
   (c) .7575, .0112, .0185, .0675, .3255.
   (d) 5.75, 10.25, 12.065, 7.285, 15.02.

PERCENTAGE

Fractions with 100 as denominator are very convenient to use in calculating and are used a great deal in the business and scientific world. These fractions are given a special name, namely, *per cent* and are denoted by the symbol %. For example, $\frac{6}{100}$ is called 6 per cent and may be written 6 %. The term per cent is a contraction of the Latin *per centum* which means by the hundred.

The strength of solutions is often expressed in percentage. Thus we may have a 10 per cent solution of sodium chloride which means that $\frac{10}{100}$ of the total amount of the solution consists of sodium chloride.

Per cent may be changed to a decimal fraction by omitting the per cent sign and expressing as hundredths decimally. Thus 1 per cent becomes .01, and 40 per cent becomes .40 or .4.

Per cent may be changed to a common fraction by writing it as the numerator (omitting the per cent sign) and 100 as the denominator of the fraction. Thus 1 per cent becomes $\frac{1}{100}$, 40 per cent $\frac{40}{100}$, $\frac{1}{2}$ per cent $\frac{\frac{1}{2}}{100}$ or $\frac{1}{200}$.

To change a decimal fraction to per cent multiply by 100 and write as a whole number with the per cent sign. Thus .5 × 100 = 50 per cent, .05 × 100 = 5 per cent, .005 × 100 = .5 per cent.

A common fraction may be changed to per cent by changing to a decimal and multiplying the resulting decimal by 100. Thus $\frac{1}{2}$ = .5 × 100 = 50 per cent.

To determine what a certain per cent of any number is, one multiplies the number by the per cent expressed as a common or decimal fraction. Thus 5 per cent of 600 = 600 × $\frac{5}{100}$ = 30. To determine what per cent any quantity is of a larger quantity, it is only necessary to divide the smaller quantity by the larger and multiply the quotient by 100.

Exercises in Percentage

1. Change the following to decimal fractions:
   5 per cent, 25 per cent, 45 per cent, 50 per cent, 80 per cent, .5 per cent, .25 per cent, .05 per cent.
2. Change to common fractions and reduce to lowest terms:
   3 per cent, 6 per cent, 8 per cent, 11 per cent, 18 per cent, 20 per cent, $33\frac{1}{3}$ per cent, $66\frac{2}{3}$ per cent.
3. Change the following fractions to percentage:
   (a) $\frac{1}{2}$, $\frac{1}{4}$, $\frac{3}{4}$, $\frac{1}{5}$, $\frac{2}{5}$, $\frac{4}{5}$, $\frac{3}{10}$, $\frac{13}{50}$.
   (b) .3, .7, .03, .07, .005, .05, .5, .15.
4. Find
   (a) 20 per cent of 400
   (b) 25 per cent of 6000
   (c) $12\frac{1}{2}$ per cent of 720
   (d) $\frac{1}{2}$ per cent of 500
   (e) $11\frac{1}{9}$ per cent of 2700
   (f) $62\frac{1}{2}$ per cent of 1600
5. What per cent of,
   (a) 25 is 20
   (b) 100 is 60
   (c) 11 is 4
   (d) 8.4 is 1.4
   (e) $\frac{7}{9}$ is $\frac{5}{9}$
   (f) 25 is $6\frac{1}{4}$

RATIO

The term *ratio* comes from the Latin word meaning relation or connection and is used in arithmetic to indicate the relation of one quantity to another. Each number of the ratio is called a term and the ratio is written with a colon between the terms. The ratio 1:1000 means that for every 1000 parts of a substance there is one part of another substance. Expressed in the form of a common fraction the above ratio becomes $\frac{1}{1000}$, or .001 as a decimal fraction. The strength of a solution may be expressed in the form of a ratio. In a 1:1000 solution of bichloride of mercury there is one part of bichloride of mercury in every 1000 parts of solution.

A common fraction may be changed to ratio by writing the numerator as the first term and the denominator as the second term of the ratio. Per cent may be changed to ratio by writing it in the form of a fraction, reducing the fraction to its lowest terms and then writing the fraction in the form of a ratio. Thus 20 per cent = $\frac{20}{100} = \frac{1}{5}$ = 1:5. Ratio may be changed to per cent by writing it as a common fraction and then changing the fraction to per cent.

QUESTIONS FOR CLASS DISCUSSION

1. Name the two systems of representing numbers.
2. What is a fraction?
3. Into what two classes are fractions divided?
4. Of what parts does a common fraction consist?
5. What is meant by the "terms" of a fraction?
6. Define, (a) proper fraction, (b) improper fraction (c) mixed number (d) complex fraction.
7. What is meant by reducing a fraction to its lowest terms?
8. How is the addition of common fractions carried out? Subtraction?
9. What is the rule for the multiplication of common fractions?
10. What is cancellation?
11. State the rule for the division of common fractions.
12. What is a decimal fraction?
13. In the number 0.261853 give the place value of each digit.
14. How may a common fraction be converted into a decimal?
15. What is the rule for the addition of decimals? Subtraction?
16. State the rule for the multiplication of decimals.
17. Give the rule for the division of decimals.
18. What is the meaning of the term per cent?
19. What fractional part of anything is 6 per cent?
20. What per cent of anything is the whole of it?
21. How may per cent be changed to a decimal fraction? Common fraction?
22. How may a common fraction be changed to per cent? Decimal fraction?
23. What is the meaning of the term ratio?
24. How is a ratio written?
25. How may a ratio be changed to a common fraction? Decimal fraction?
26. How may per cent be changed to ratio?

CHAPTER VIII

WEIGHTS AND MEASURES

- Metric System.
  - Origin.
  - Terminology.
  - Tables.
  - Exercises.
- Apothecaries' System.
  - Tables.
  - Converting One Denomination into Another.
  - Exercises.
- Approximate Equivalents.
- Converting One System into the Other.
  - Rules.
  - Exercises.
- Review Exercises.

In order to prepare solutions and doses the student must be acquainted with the systems of weights and measures in use. At the present time there are two systems used in the United States for weighing and measuring drugs, namely, the *metric* and *apothecaries'*. It is necessary for the student to have a practical knowledge of each system. The subject which deals with the study of weights and measures is known as *metrology*. The term *weight* refers to the measure of the force with which the earth draws objects to its center. The term *volume* refers to the amount of space that a body occupies.

METRIC SYSTEM

The word metric comes from the Greek word *metron* which signifies measure. This system has been adopted and its use made obligatory in many countries of the world. Its use has been legalized in the United States but has not been made compulsory. Several attempts have been made to make it the standard system of weights and measures in the United States and probably this will come to pass in the future for its use is constantly extending. It is now used in the sciences, in weighing at the mints, weighing foreign mail, and in pharmacy. In the medical departments of the United States Army and Navy it is used exclusively.

Origin.—This system was devised in France and adopted by the French Government in the eighteenth century soon after the French Revolution. A committee of the Academy of Sciences was appointed for this purpose. The aim of this committee was to devise a system based upon a natural measure on the surface of the earth and to take advantage of the convenience of the decimal scale.

To obtain a natural unit they took the ten-millionth part of the distance from the equator to the north pole, measured on the meridian passing through Paris. This was called the *meter* and constituted the unit of length (linear measure). The meter is also the *fundamental unit* of the whole system for the units of volume and weight were derived from it. A re-measurement of the meridian showed that the first measurement was incorrect. The length of the meter, as based upon the erroneous measure was, however, retained.

A *standard meter* was made of a bar of special platinum alloy and two scratches were made on the surface, one near each end. The distance between the two scratches is exactly one meter when the bar is at the temperature of melting ice. This bar is kept in an underground vault in the International

Bureau of Weights and Measures, near Paris. Twenty eight countries are members of the international bureau and each has received two copies of the standard meter. The United States has two copies in the National Bureau of Standards at Washington, D. C.

Terminology.—Multiples and subdivisions of the unit were obtained by the use of decimals. For multiples the Greek prefixes *deka*, *hecto*, and *kilo* were used, while for the sub-divisions the Latin prefixes, *deci*, *centi*, and *milli* were selected. The following table gives the value of these terms in relation to the unit:

Kilo (kĭlō)	1000
Hecto (hĕktō)	100
Deka (dĕka)	10
Unit—Meter, Liter or Gram	1
Deci (dĕsĭ)	0.1
Centi (sĕntĭ)	0.01
Milli (mĭlĭ)	0.001

This table shows that the whole system is based on a decimal ratio. Ten of one order are equal to one of the next higher order. It is similar to our money system in which there are ten mills to a cent, ten cents to a dime, and ten dimes to a dollar.

TABLES

Table of Linear Measure

10 millimeters (mm.) = 1 centimeter (cm.)
10 centimeters = 1 decimeter (dm.)
10 decimeters = 1 meter (M.)
10 meters = 1 dekameter (Dm.)
10 dekameters = 1 hectometer (Hm.)
10 hectometers = 1 kilometer (Km.)

The unit of capacity is the *liter*. It represents the volume of one-tenth of a meter (decimeter) cubed.

The liter is thus based upon the fundamental unit, the meter. The same prefixes are used with the liter as with the meter.

Table of Capacity

10 milliliters (ml.) = 1 centiliter (cl.)
10 centiliters = 1 deciliter (dl.)
10 deciliters = 1 liter (L.)
10 liters = 1 dekaliter (Dl.)
10 dekaliters = 1 hectoliter (Hl.)
10 hectoliters = 1 kiloliter (Kl.)

The term *milliliter* is seldom used but in its place the term cubic centimeter (cc.) is used.

The *gram*, which is the unit of weight, is the weight of a volume of water equal to one-hundredth of a meter (centimeter) cubed. In accurately determining this, distilled water at the temperature of its greatest density (4°C.) was used. The gram as well as the liter is, therefore, based upon the fundamental unit, the meter. The official abbreviation of the word gram as used in the Pharmacopœia is Gm.

Table of Weight

10 milligrams (mg.) = 1 centigram (cg.)
10 centigrams = 1 decigram (dg.)
10 decigrams = 1 gram (Gm.)
10 grams = 1 dekagram (Dg.)
10 dekagrams = 1 hectogram (Hg.)
10 hectograms = 1 kilogram (Kg.)

The denominations centigram and decigram are seldom used to express quantities. Very small quantities are sometimes expressed in milligrams. All quantities less than a gram are usually expressed as fractions of a gram. Thus 80 milligrams may be written 0.08 gram, and 7 decigrams as 0.7 gram.

In prescriptions in which the quantities are in the metric system a decimal point and a zero are generally used. Thus one gram is written 1.0, one decigram 0.1. The pharmacist understands that the quantities are metric and therefore the abbreviations for gram or cubic centimeter are not necessary. This method of indicating metric quantities prevents confusion with the apothecaries' system.

Since one cubic centimeter of water weighs a gram these two terms are used interchangeably when dealing with solutions. To be exact the water must be pure and at 4°C. or a cubic centimeter will not weigh a gram, but a cubic centimeter of ordinary water at room temperature comes so near to weighing a gram that it may be considered to do so in routine work.

The chief merits of the metric system are: (1) every weight and measure bears a simple relation to the fundamental unit, the meter; (2) it is easy to work with because of its uniform decimal nature; (3) it is a universal system.

EXERCISES

1. Give the value of the following prefixes in relation to the unit: (a) milli, (b) kilo, (c) deci, (d) centi, (e) hecto, (f) deka.

2. Give the metric prefixes of the following quantities applying them to (1) meter, (2) liter, (3) gram: (a) 0.1, (b) 1000.0, (c) 0.01, (d) 100.0, (e) 0.001, (f) 10.0.

3. Convert into grams: (a) 4000 mg., (b) 460 dg., (c) 24 cg., (d) 64 mg.

4. Convert into milligrams: (a) 4 Gm., (b) 5 dg., (c) 44 cg., (d) 53 dg., (e) 0.402 Gm.

5. Add and express in grams:

   (a) 4 Gm., 6 dg., 8 cg., 12 mg.
   (b) 8 mg., 5 Gm., 7 dg., 4 cg.
   (c) 9 dg., 45 cg., 4.8 Gm., 175 mg.

6. Add and express in milligrams:
   (a) 6 mg., 2 dg., 3 cg.
   (b) 3 dg., 2 cg., 65 mg.

7. Subtract 20 milliliters from 0.5 of a liter and give the answer in cubic centimeters.

APOTHECARIES' SYSTEM

The Apothecaries' system of weights and measures is a part of the English system and has been in use in the United States since Colonial times in the compounding of prescriptions. The unit of weight is the *grain*.

TABLES

Table of Weights

20 grains (gr.) = 1 scruple (℈)
3 scruples or 60 grains = 1 dram (ʒ)
8 drams or 480 grains = 1 ounce (℥)
12 ounces or 5760 grains = 1 pound (lb.)

The scruple is seldom used in expressing quantities, all quantities less than a dram being expressed in grains. The word dram is sometimes written "drachm."

The unit of liquid measure is the *minim*. A minim of water weighs approximately a grain (60 minims of water weigh 55 grains).

Table of Fluid Measure

60 minims (♏) = 1 fluidram (ʒ)
8 fluidrams or 480 minims = 1 fluidounce (℥)
16 fluidounces = 1 pint (pt. or O.)
2 pints = 1 quart (qt.)
4 quarts = 1 gallon (gal. or C.)

A minim of water or an aqueous solution is equal approximately to a *drop*. In alcoholic solutions, such as fluidextract of ipecac or tincture of digitalis, two drops equal approximately a minim. A minim of ether consists of three drops, while it takes four drops to make a minim of chloroform. Gummy substances produce drops that are larger than minims.

To measure minims accurately a minim graduate or pipette must be used. When a natural drop is intended the word *gutta* (gtt.) is used instead of minim. A medicine dropper may be used to measure drops.

In writing prescriptions in the apothecaries' system physicians use the symbols and Roman numerals. The symbol is written first and is followed by the quantity. For example, 6 grains is written, gr. vi; 2 drams, ʒii or ʒij; 4 ounces, ℥iv. The quantity ½ may be expressed by the symbol "ss." Other fractions are expressed in Arabic numerals.

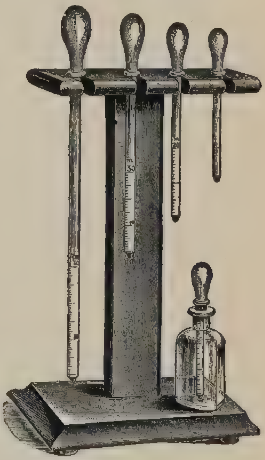

FIG. 23.—Squibb's minim pipettes.

The symbol "O" for pint has been derived from the Latin word "*octarius*," "C" for gallon from the word "*congius*," and "lb." from "*libra*" meaning pound.

480
2
960

Converting One Denomination into Another.—To change from a higher to a lower denomination it is only necessary to multiply by the number of the lower that the higher contains. Thus to change 3 quarts to pints one multiplies by 2 since a quart contains 2 pints. To change pints to ounces multiply by 16, ounces to drams multiply by 8, and drams to minims or grains multiply by 60.

To change from a lower to a higher denomination the process is reversed and instead of multiplying one divides. Thus to change 120 grains to drams, one divides by 60 since a dram contains 60 grains. The following problem shows how to proceed when there is a remainder after carrying out the division:

Change 1200 grains to higher denominations.
1200 ÷ 480 = 2 ounces + a remainder of 340 grains
340 ÷ 60 = 5 drams + a remainder of 40 grains.

The 40 grains could be changed to scruples but since quantities are not expressed in scruples it remains in the form of grains. The answer, therefore, is 2 ounces, 5 drams, and 40 grains.

EXERCISES

1. Read the following:

(a) gr. XLV
(b) ʒviii
(c) f.℥vi
(d) ♏.xxi
(e) ʒiiss
(f) gr. ij
(g) ʒix
(h) f.℥ss

2. Determine the number of grains in,

(a) ʒi
(b) ℥iv
(c) ℥ii
(d) ʒviss
(e) ʒiiss
(f) ʒss
(g) ℥ss
(h) ℥viii
(i) lb. i
(j) ʒvi

3. Determine the number of minims in,

(a) f.℥i
(b) f.ʒi
(c) Oi
(d) f.℥ss
(e) f.ʒiiss
(f) Oss
(g) f.ʒiij
(h) f.℥xvi
(i) f.ʒiv
(j) Oiiss

4. Add and give the answer in grains:

(a) ʒiij, ℥ij, ʒviii.
(b) ʒiv, ℥xii, gr. XL.
(c) lb. i, ℥ix, ʒvi.

5. Change,

(a) 3 pints to fluidrams.
(b) 2 quarts to fluidounces.
(c) 2 pints, 3 fluidounces to minims.
(d) 1 gallon, 1 pint, 1 fluidounce, 8 fluidrams to minims.
(e) 1 pound, 3 ounces, 9 drams to grains.

6. Change to higher denominations:

(a) 16 ounces
(b) 40 drams
(c) 1000 minims
(d) 150,000 grains
(e) 20,000 minims
(f) 48 fluid ounces

APPROXIMATE EQUIVALENTS

Since two systems are used in weighing and measuring drugs it is of practical value to know the relation between the units of the two systems. The student should memorize the approximate equivalents given in the table below.

TABLE OF APPROXIMATE EQUIVALENTS

1 grain = 0.065 Gm.
1 minim = 0.065 cc.
15 grains = 1 Gm.
15 minims = 1 cc.
1 dram = 4 Gm.
1 fluidram = 4 cc.
1 ounce = 30 Gm.
1 fluidounce = 30 cc.
1 pint = 500 cc.
1 quart = 1000 cc.

CONVERTING ONE SYSTEM INTO THE OTHER

Since a gram is equal approximately to 15 grains, grams may be converted into grains by multiplying by 15. Grains may be converted into grams by multiplying by 0.065 because a grain is equal to that fraction of a gram. To convert grams into ounces divide by 30 and ounces into grams, multiply by 30. To convert grams into drams divide by 4, and drams into grams multiply by 4.

RULES

The above statements may be formulated into the following sets of rules.

METRIC TO APOTHECARIES'

Rule 1. To convert grams (or cc.) into grains (or minims) multiply by 15 or divide by 0.065.

Rule 2. To convert grams into drams (or cubic centimeters into fluidrams) divide by 4.

Rule 3. To convert grams into ounces (or cubic centimeters into fluidounces) divide by 30.

Apothecaries' to Metric

Rule 1. To convert grains into grams (or minims into cubic centimeters) multiply by 0.065 or divide by 15.

Rule 2. To convert drams into grams (or fluidrams into cubic centimeters) multiply by 4.

Rule 3. To convert ounces into grams (or fluidounces into cubic centimeters) multiply by 30.

EXERCISES

1. Convert the following into cubic centimeters:

(a) f.℥ii
(b) f.ʒvi
(c) ♏.xxv
(d) ♏.iss
(e) f.℥iss
(f) ♏.LX
(g) ♏.xxxvi
(h) Oiii

2. Change the following to grams:

(a) ℥iii
(b) gr. x
(c) ʒv
(d) gr. LX
(e) ʒxxxv
(f) gr. iii
(g) lb.ii
(h) gr. iss

3. Change to Apothecaries':

(a) 2.5 Gm.
(b) 3.4 cc.
(c) 350 Gm.
(d) 0.26 Gm.
(e) 0.4 cc.
(f) 0.02 Gm.
(g) 0.015 Gm.
(h) 0.003 Gm.

4. Convert into Metric:

(a) gr. $\frac{1}{4}$
(b) gr. $\frac{1}{3}$
(c) gr. $\frac{1}{60}$
(d) gr. $\frac{1}{6}$
(e) gr. $\frac{1}{8}$
(f) gr. $\frac{1}{50}$
(g) gr. $\frac{1}{2}$
(h) gr. $\frac{1}{100}$
(i) gr. $\frac{1}{250}$
(j) gr. $\frac{1}{5}$
(k) gr. $\frac{1}{10}$
(l) gr. $\frac{1}{400}$

5. Change the following prescription into metric units:

℞

Morphinae Sulphatis	gr. iii
Sodii Bromidi	ʒ ii
Syrupi Auranti	℥ i
Aquae Cinnamomi, q.s. (ad.)	℥ iv

REVIEW EXERCISES

1. How many ounces are there in an Apothecaries' pound?
2. What is the number of fluid ounces in a quart? Gallon?

3. How many minims in a pint? Quart?
4. Give the number of fluidrams in, (1) a pint, (2) a quart.
5. Reduce 3 quarts, 1 pint and 6 ounces to minims.
6. Change 5 pints to ounces.
7. Change 15,735 minims to higher denominations.
8. Reduce Oi, f.℥x, f.ʒii to minims.
9. Add ℥v, ʒiv, gr. iiss and express in grains.
10. Subtract 1 quart, 5 fluidounces, 3 fluidrams and 14 minims from 1 gallon.
11. What is the weight in grams of 15 cc. of water? one liter?
12. How many milligrams are there in 40 dekagrams?
13. How many cubic centimeters in 10 milliliters?
14. Give the number of grams in one liter of water.
15. What is the number of milliliters in one liter?
16. How many cubic centimeters are there in a liter?
17. Give the equivalent in milliliters of 15.6 liters.
18. After removing 15 cubic centimeters, 10 deciliters, and 20 centiliters from a 1.5 liter bottle of cresol solution, how many milliliters remain?
19. How many milligrams would remain of 6.9 grams of salt after removing 60 decigrams?
20. Give the approximate number of milliliters in a pint.
21. How many cubic centimeters in a pint?
22. What is the weight of a pint of water in grams?
23. How many cubic centimeters in a quart?
24. Give the number of liters in a gallon.
25. State the number of, (1) grains in a gram, (2) minims in a gram of water, (3) minims in a cubic centimeter.
26 How many fluid ounces in a liter?
27. Give the number of cubic centimeters in a gallon.
28. How many grams in an ounce? minims in a fluid ounce?
29. What is the difference in grains between 10 ounces and 1 pound?
30. State the number of, (1) cubic centimeters in a fluidram, (2) minims in 0.5 liter, (3) ounces in 500 grams, (4) minims in 25 cubic centimeters.

Questions for Class Discussion

1. Name the two systems used in weighing and measuring drugs.
2. What is the fundamental unit in the metric system?
3. How was this unit obtained?
4. Name the subdivisions of the meter? Multiples?
5. What is the metric unit of capacity?

6. How was this unit obtained?
7. What name has been applied to the .001 part of a liter?
8. Name the metric unit of weight and explain how it was obtained.
9. Name the subdivisions and multiples of the liter and gram.
10. What part of a liter is a milliliter? What part of a centigram is a milligram? A centimeter is what part of a decimeter?
11. How many grams are there in a kilogram?
12. How many cubic centimeters does a liter contain?
13. What are the chief merits of the metric system?
14. Give the apothecaries' table of weight.
15. State the apothecaries' table of fluid measure.
16. What is the difference between a drop and a minim?
17. How many grains in a dram? Ounce?
18. Give the rule for converting grams into grains.
19. State the rule for changing grains to grams.
20. Give the approximate metric equivalents of the following: (a) 1 grain, (b) 1 ounce, (c) 0.065 grain, (d) 1 minim, (e) 1 quart, (f) 15 grains, (g) 1 pint, (h) 1 dram.

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CHAPTER IX

SOLUTIONS

Nature of Solutions.
Common Solvents.
Solubility.
Strength of Solution.
Determination of Strength.
Problems.
Ionization.
Hydrogen Ion Concentration.
Osmotic Pressure.
Solutions for Infusion.
Colloidal Solutions.

Since many medicinal substances are used in the form of solutions it is necessary for the student to have a thorough understanding of the principles of solutions.

NATURE OF SOLUTIONS

When a small amount of table salt is added to water and shaken, the salt quickly disappears and a homogeneous fluid results, in which particles of salt cannot be detected even under the microscope. The salt will not settle out on standing, nor can it be removed by filtration. However, when the water is evaporated the salt can be regained in its original form. *Solution* is the separation of the molecules of a substance and their diffusion through a liquid. A solution in which the solute dissolves without chemical change is called a *simple solution.* When the active ingredients are formed in the process of solution as the result of chemical action a *chemical solution* results.

If powdered chalk is shaken up with water the chalk becomes distributed more or less uniformly, but the particles can be seen in the fluid and give it a milky appearance. On standing the chalk particles settle to the bottom. The chalk can be removed by filtration. Such a preparation is not a solution but is called a *mixture* or *suspension*. When a fixed oil is vigorously shaken with water, the oil breaks up into fine globules distributed uniformly throughout the liquid. On standing, however, the oil separates from the water. Such a preparation is called an *emulsion* and is not a solution.

A *true solution* is characterized by homogeneity, absence of settling, and a fine state of subdivision into molecules or ions on the part of the dissolved substance. That part of the solution which acts as the dissolving agent is called the *solvent*, while the substance dissolved by the solvent is termed the *solute*. The solute may be a solid, a liquid or a gas. The solvent is usually a liquid but may be a solid or a gas.

COMMON SOLVENTS

In pharmaceutical solutions the solvent is always a liquid. Water is a solvent commonly used but alcohol, glycerin, oils, acids, ether, and chloroform are also employed. Most inorganic substances dissolve readily in water, while many of the organic substances used in therapeutics dissolve better in alcohol or other solvents. More substances are soluble in water than in any other solvent. Most salts, sugars and gums are readily soluble in water. Alcohol dissolves resins, volatile oils, and alkaloids. Ether dissolves fats, resins, alkaloids, and volatile oils. Glycerin dissolves boric acid and is a good general solvent.

When water is the solvent the solution is known as an *aqueous solution,* while a solution made with alcohol as the solvent is termed an *alcoholic solution.* When the solvent consists of alcohol diluted with water the term *hydro-alcoholic solution* may be used.

In pharmacy the solute is usually a solid or liquid but it may be a gas. An example of a solution in which a gas is dissolved in a liquid is chlorine water which is used as an antiseptic. One liquid may be dissolved in another, as for example, alcohol in water or a volatile oil in alcohol.

SOLUBILITY

The term *solubility* means the extent to which a substance is capable of being dissolved in a given volume of a solvent. Most substances when placed in a liquid in which they are soluble will not dissolve in unlimited quantities. Some substances dissolve in less than their own weight of solvent while others require many times their own weight. Although theoretically no substance is absolutely insoluble, some substances are to all practical purposes insoluble, others are moderately soluble, while still others are very soluble. Solution may be hastened by using solids in the form of powder, by agitation, and usually by heat.

When a liquid has dissolved as much of a solute as it is capable of holding at ordinary temperatures (about 25°C.) the solution is said to be *saturated.* The term saturated refers to limit of solubility rather

TABLE OF SOLUBILITY

Substance	Number of grams soluble in 100 grams of water at 25°C. (77°F.)	Number of grams soluble in 100 grams of alcohol at 25°C (77°F.)
Acriflavine	33	Very soluble
Alcohol	Miscible in all proportions	
Alum (Ammonium)	19	Insoluble
Alum (Potassium)	14	Insoluble
Boric Acid	5.5	5.5
Bismuth Subcarbonate	Insoluble	Insoluble
Bismuth Subnitrate	Insoluble	Insoluble
Calcium Oxide (Lime)	0.12	Insoluble
Calcium Lactate	5	Insoluble
Camphor	0.12	Very soluble
Castor Oil	Insoluble	100
Chlorinated Lime	Partly soluble	Partly soluble
Chloramine	16.5	Decomposes
Chloroform	0.48	Miscible in all proportions
Citric Acid	200	56
Cod Liver Oil	Insoluble	Slightly soluble
Copper Sulphate	40	0.2
Creosote	Nearly insoluble	Miscible in all proportions
Cresol	2	Miscible in all proportions
Dextrose	100	1.7
Dichloramine	Slightly soluble	Decomposes
Eucalyptol	Nearly insoluble	Very soluble
Ferric Chloride	500	Very soluble
Formaldehyde Solution	Miscible in all proportions	Miscible in all proportions
Gentian Violet	10	10
Glycerin	Miscible in all proportions	Miscible in all proportions
Iodine	0.03	10
Iodoform	0.01	1.7
Lead Acetate	71.5	2.7
Magnesium Sulphate	77	Insoluble
Menthol	Nearly insoluble	Very soluble
Mercuric Chloride	7.4	26
Mercurochrome	Very soluble	Insoluble
Oil of Clove	Insoluble	Very soluble
Oil of Wintergreen	Insoluble	Miscible in all proportions

TABLE OF SOLUBILITY.—(*Continued*)

Substance	Number of grams soluble in 100 grams of water at 25°C. (77°F.)	Number of grams soluble in 100 grams of alcohol at 25°C. (77°F.)
Phenol	6.7	Misible in all proportions
Phenolphthalein	Insoluble	7.7
Potassium Acetate	200	34
Potassium Bicarbonate	36	Insoluble
Potassium Chlorate	8.7	Insoluble
Potassium Citrate	167	Insoluble
Potassium and Sodium Tartrate	111	Insoluble
Potassium Hydroxide	111	33
Potassium Iodide	143	45
Resorcinol	111	111
Procaine Hydrochloride	167	3.3
Silver Protein, Mild	Very soluble	Insoluble
Silver Protein, Strong	Very soluble	Insoluble
Silver Nitrate	250	3.3
Sodium Acetate	125	5.3
Sodium Bicarbonate	10	Insoluble
Sodium Borate	6.7	Insoluble
Sodium Cacodylate	200	40
Sodium Carbonate (monohydrated)	33.3	Insoluble
Sodium Chloride	36	Insoluble
Sodium Citrate	77	Insoluble
Sodium Hydroxide	111	Very soluble
Sodium Iodide	200	33
Sodium Sulphate	50	Insoluble
Sodium Thiosulphate	200	Insoluble
Sucrose	200	0.6
Tannic Acid	Very soluble	Very soluble
Tartaric Acid	133	33
Thymol	0.09	100
Picric Acid (Trinitrophenol)	1.2	8.3
Zinc Acetate	43.5	3.3
Zinc Chloride	400	77
Zinc Oxide	Insoluble	Insoluble
Zinc Stearate	Insoluble	Insoluble
Zinc Sulphate	167	Insoluble

than to a high concentration of solute in solvent. Some solutions are saturated in a concentration of .03 per cent while others do not reach the saturation point until they obtain a strength of 90 per cent.

Two saturated solutions in common use are saturated solution of boric acid (5 per cent) and saturated solution of magnesium sulphate (44 per cent). In some cases there is no limit to solubility. Such solutions cannot reach the saturation point. Alcohol, for example, will dissolve in water in any proportion. This is also true of glycerin. Such substances are said to be *miscible* in all proportions.

When a saturated solution is heated more solute can usually be dissolved in it. When such a solution is cooled the excess solute forms crystals. There are a few solutions which when saturated at high temperatures may be cooled without the excess solute crystallizing out. Such solutions are known as *supersaturated* solutions. When crystals of the solute are added to a supersaturated solution the excess solute usually crystallizes out.

STRENGTH OF SOLUTION

The term *strength* applied to a solution refers to the amount of solute contained in a certain amount of solution. When a solution contains a small proportion of solute it is called a *dilute* solution, while a *concentrated* solution is one which contains a relatively large proportion of the dissolved substance. The term *concentration* refers to the relative quantities of solute and solvent and is similar to the term strength as applied to solutions. The concentration, for example, may be 1 per cent, 10 per cent, or 75 per cent.

DETERMINATION OF STRENGTH

The concentration of a solution can be determined if the amount of solute and the total amount of solution are known, and may be expressed in the form of percentage strength or ratio strength. To determine the *percentage strength,* the amount of solute is divided by the total amount of solution and multiplied by 100. This may be stated as a formula as follows:

$$\frac{\text{Solute}}{\text{Solution}} \times 100 = \text{per cent}$$

Example: A 100 cc. solution contains one gram of phenol. What is the percentage strength?

$$\tfrac{1}{100} \times 100 = 1 \text{ per cent}$$

To determine the *ratio strength* of a solution the total amount of solution is divided by the amount of solute. This gives the second term of the ratio. The first term need not be determined since it is always one in the type of ratio used to express the strength of solutions. This rule may be formulated as follows:

$$\text{Solution} \div \text{solute} = \text{second term of ratio}$$

Example: A 100 cc. solution contains one gram of phenol. What is the ratio strength?

100 ÷ 1 = 100. The ratio strength, therefore, is 1:100.

Sometimes it is necessary to convert *percentage strength into ratio strength.* This may be done by dividing 100 by the percentage strength. The result is the second term of the ratio.

$$100 \div \text{per cent} = \text{second term of ratio.}$$

Example: Change 1 per cent to ratio strength.

100 ÷ 1 = 100. The ratio strength, therefore, is 1:100

To change *ratio to percentage* write the ratio as a common fraction by using the first term as the numerator and the second as the denominator and multiply by 100.

$$\frac{1st\ \text{term}}{2nd\ \text{term}} \times 100 = \text{per cent}$$

Example: Change 1:100 to percentage strength.

$$\tfrac{1}{100} \times 100 = 1 \text{ per cent}$$

PROBLEMS

Percentage and Ratio Strength

1. If a solution contains 0.5 gram of drug to 100 cubic centimeters, what is the percentage strength?
2. What is the percentage strength of a pint of solution which contains 15 grains of drug?
3. Determine the ratio strength of a liter of solution that contains 200 grams of a drug.
4. Give the ratio strength of a 500 cc. solution containing two 7½ grain tablets of mercuric chloride.
5. One grain of silver nitrate is dissolved in 50 minims of water. What is the percentage strength?
6. If 5 teaspoonfuls of glycerin are added to 10 teaspoonfuls of water, what is the percentage strength of the solution formed?
7. What is the ratio strength of 150 cc. of solution that contains 25 cc. of alcohol?
8. A one ounce solution contains 30 grains of phenol. What is the percentage strength?
9. Determine the percentage strength of a solution of 8 ounces which contains 5 grams of phenol.
10. If a dram of solution contains two grains of a drug what is the ratio strength?
11. What is the percentage strength of a solution containing 50 grams of solute in one liter of solution?
12. If a solution contains one dram of solute in 80 cc. what is the percentage strength?
13. Ten ounces of solution contain 6 drams of silver nitrate. What is the percentage strength?
14. What is the ratio strength of a pint of solution containing 1½ drams of a drug?
15. If one pint of solution contains two drams of phenol what is the percentage strength?
16. Determine the percentage strength of one quart of solution which contains an ounce of alcohol.

17. Twenty cubic centimeters of solution contain 15 grains of salt, what is the percentage strength?

18. If 2 drams of solution contain 40 grains of a drug, what is the ratio strength?

Percentage to Ratio and Vice Versa

1. Change the following ratios to percentage:

(a) 1:5
(b) 1:20
(c) 1:100
(d) 1:25
(e) 1:3
(f) 1:40
(g) 1:$12\frac{1}{2}$
(h) 1:5000
(i) 1:10000
(j) 1:200
(k) 1:500
(l) 1:1000

2. Change the following to ratio strength:

(a) 10 per cent
(b) $33\frac{1}{3}$ per cent
(c) 0.1 per cent
(d) 5 per cent
(e) 0.5 per cent
(f) 30 per cent
(g) 2 per cent
(h) $\frac{1}{5}$ per cent
(i) 50 per cent
(j) $\frac{1}{20}$ per cent
(k) 0.01 per cent
(l) 16 per cent

IONIZATION

When an aqueous solution is made of an acid, a base, or a salt the molecules of these substances break down into minute particles known as *ions.* This breaking down or dissociation into ions is known as *ionization.* Solutions which ionize are called *electrolytes* because they conduct an electric current. Solutions which do not ionize do not conduct an electric current.

A molecule always dissociates into two ions, bearing opposite electric charges, one *positive* the other *negative.* Ions in some cases are atoms, while in other cases they are groups of atoms (radicals). Dissociation into ions is never complete as there are always some undissociated molecules along with positively and negatively charged ions.

When an aqueous solution of sodium chloride is made, the sodium chloride molecules dissociate, more or less completely, into positively charged *sodium ions* and negatively charged *chlorine ions.* When this solution is evaporated the ions recombine and their electric charges neutralize each other. The molecule as a whole, therefore, is not electrified.

The chemical reactions of acids, bases, and salts are due almost entirely to the reactions of their ions. Salts as a rule are highly ionized in solution while bases and acids form two classes, those that are strong or highly ionized, and those that are weak or slightly ionized. Acids are distinguished by the fact that they yield hydrogen ions while bases form hydroxyl (OH) ions. An aqueous solution of a base also contains a small quantity of hydrogen ions. Since the chemical reactions of acids and bases are due to the reactions of their ions and since ionization is never complete the only accurate way to determine acidity or alkalinity is to determine the concentration of hydrogen ions.

HYDROGEN ION CONCENTRATION

A *neutral solution* is one which contains hydrogen and hydroxyl ions in equal numbers. An *acid solution* owes its acid properties to the presence of an excess of hydrogen ions, while an *alkaline solution* owes its characteristic properties to the presence of an excess of hydroxyl ions.

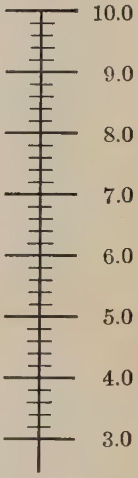
The *degree of acidity* of a solution can be determined by ascertaining the hydrogen ion concentration. In pure water, which is a neutral liquid, there are one gram of hydrogen ions and seventeen grams of hydroxyl ions in ten million liters, at room temperature. Since hydroxyl ions are seventeen times as

5%.
1:20
3:100

heavy as hydrogen ions, the number of hydroxyl ions in pure water is the same as the number of hydrogen ions.

In expressing the concentration of hydrogen ions a scale known as the *pH scale* is used. To indicate the concentration of hydrogen ions in water or neutral solutions the expression pH = 7 is used. The seven represents the power to which 10 (10^7) must be raised to yield ten million liters of liquid containing one gram of hydrogen ions.

Since acids are more highly ionized than water, the volume containing one gram of hydrogen ions is less than ten million liters. Acids therefore have a pH which is less than 7. As hydrogen ion concentration increases the pH number diminishes. Alkalies have a pH greater than 7 since more than ten million liters of an alkaline solution are required to contain one gram of hydrogen ions.



pH SCALE

In making pH measurements certain indicators, which change color when added to solutions of different acidities and alkalinities, are used. Litmus is an example of an indicator. It is inaccurate, however, chiefly because it has a very wide range and the color changes are not distinct. With indicators of short ranges the color changes are more distinct and accurate pH determinations may be made.

The hydrogen ion concentration of the *gastric juice* is of importance in digestion. A physician may determine its pH value. A concentration above normal is known as hyper-acidity, while a concentration below normal is called hypo-acidity. *Urine* is often tested for its pH value since this gives valuable information concerning the functioning of the various organs of the body.

The pH of the *body fluids* and the *blood* is maintained with great constancy. The normal variations of the blood are from pH 7.3 to 7.5. The limits compatible with life are pH 7.0 to 7.8.

Besides hydrogen ions there are *other ions* in the blood that are of importance in the physiological processes of the body. The proper balance of sodium, calcium, potassium, magnesium, and chlorine ions is essential. A change in the concentration of any one of these may produce marked effects upon the body. A high concentration of potassium ions, for example, may stop the heart. These facts have a bearing on the use of drugs in the treatment of disease.

OSMOTIC PRESSURE

All substances in solution exert a pressure known as *osmotic pressure.* Substances which ionize in solution exert a greater osmotic pressure than do non-electrolytes. Osmotic pressure depends upon the relative number of particles of the dissolved substance in the solution. Each ion increases the pressure as much as an entire molecule. If two solutions are prepared, one of common salt and the other of sugar, so that each solution will contain the same number of molecules, they will not exert the same osmotic pressure. The salt solution, due to the fact that some of the NaCl molecules are split into ions, exerts the greater pressure.

Membranes in the human body are permeable to water but vary in regard to permeability to other substances. All body membranes, therefore, may be said to be *semi-permeable.* If two solutions of different concentration are separated by a semi-permeable membrane, the greater flow will always be from the more dilute to the more concentrated.

Osmotic pressure may be defined as the force with which a solution holds or attracts water. It is only necessary to separate a weaker from a stronger solution by means of a semi-permeable membrane to bring osmotic pressure into evidence. The passage of a liquid in this manner through a membrane is called *osmosis.*

A solution that has the same osmotic pressure that the blood has is said to be *isotonic* with the blood. If the osmotic pressure is less than that of the blood it is called *hypotonic* and if greater than that of the blood, *hypertonic.* Both hypotonic and hypertonic solutions change the composition of the cells they come in contact with. When red blood corpuscles are placed in a hypotonic solution they swell and may even burst. When blood corpuscles have been broken up in this way the blood is said to have been *laked.* In a hypertonic solution blood corpuscles shrink.

Osmotic pressure plays an important part in the physiological processes of the body. The solutions that come in contact with the tissues of the body must have a suitable osmotic pressure, so that the tissues will not be damaged by changing their water content.

SOLUTIONS FOR INFUSION

In an *infusion* a large quantity of fluid is introduced into the blood stream. It must be isotonic with the blood to avoid injury to the blood corpuscles. It must also be slightly alkaline in reaction to avoid damage to tissues by hydrogen ions. Isotonicity and reaction, however, are not the only factors to be considered. It should also contain sodium, potassium, and calcium ions in the proportions in which they occur in the blood.

The following solutions are often employed for infusion.

1. **Physiological Salt Solution.**—This is also known as normal saline solution but is not a normal solution in the chemical sense. It contains 0.85 per cent of sodium chloride and is isotonic with the blood. Since it does not contain potassium and calcium ions, and is not alkaline in reaction it is not the best solution to use.

2. **Locke-Ringer's Solution.**—This is probably the best solution for infusion purposes. It usually has the following composition:

Sodium Chloride	9.0 Gm.
Potassium Chloride	0.42 Gm.
Calcium Chloride	0.24 Gm.
Magnesium Chloride	0.005 Gm.
Sodium Bicarbonate	0.5 Gm.
Dextrose	0.5 Gm.
Distilled Water, to make	1000.0 cc.

3. **Dawson's Solution.**—This solution contains 0.8 per cent of sodium chloride and 0.5 per cent of sodium bicarbonate.

4. **Glucose Solution.**—This is a 10 to 15 per cent solution of dextrose (glucose) in water or physiological salt solution.

Solutions for infusion must be sterilized before they are used.

COLLOIDAL SOLUTIONS

The student is now ready to understand that there are three kinds of solutions, namely; (1) *molecular solutions*, in which the dissolved substance is present in the form of its molecules; (2) *ionic solutions*, in which the solute dissociates into electrically charged ions; and (3) *colloidal solutions*, in which the individual particles are relatively large. Colloidal solutions are not true solutions but are suspensions. They are not homogeneous in their make-up but consist of relatively large particles dispersed through the liquid. These particles are either large molecules or clusters of molecules. Colloidal solutions resemble true solutions in that they may be filtered without leaving any solid substance on the filter paper.

When a beam of light is passed through a colloidal solution in a dark room, minute points of light can be seen in the liquid. These points of light are due to minute suspended particles which reflect the light. A true solution remains perfectly dark under these conditions. The particles in suspension in a colloidal solution are constantly in motion. This motion, known as the *Brownian movement*, is due to the fact that the molecules of water are constantly in motion and bombard the suspended particles, pushing them from side to side and up and down.

Examples of colloids are gelatin, glue, gum, and albumin. Living substance is made up largely of colloidal material. Colloidal solutions of silver are used extensively in therapeutics in treating diseases of the eyes, ears, nose and throat. Other colloidal solutions in use are aluminum hydroxide, and colloidal sulphides of arsenic and mercury.

Questions for Class Discussion

1. Explain what is meant by solution.
2. What takes place when one substance dissolves in another?
3. How does a simple solution differ from a chemical solution?
4. Define, (a) solute, (b) solvent.
5. What are the principal solvents used in pharmacy?

6. What is the meaning of the term solubility?

7. What effect has temperature on solubility?

8. What is the meaning of the term saturated?

9. How does a supersaturated solution differ from a saturated solution?

10. What is meant by the strength of a solution? Concentration?

11. Explain what is meant by a 5 per cent solution?

12. State the rule for determining the percentage strength of a solution.

13. How may the ratio strength of a solution be determined?

14. How may percentage strength be converted into ratio strength? Ratio into percentage?

15. What is meant by ionization?

16. Which kinds of substances ionize in solution?

17. To which ions does an acid solution owe its properties?

18. To which ions does an alkaline solution owe its properties?

19. Explain in terms of ionization what is meant by (a) weak acid, (b) weak base, (c) strong acid, (d) strong base.

20. Why is the determination of the concentration of hydrogen ions the only accurate method of ascertaining the acidity or alkalinity of a solution?

21. What is a neutral solution in terms of ionization?

22. What is meant by the pH scale?

23. What is the pH of pure water?

24. State whether the following indicate acid, neutral, or alkaline reactions: pH 7.4, pH 6.8, pH 7.0.

25. How are pH measurements made?

26. Of what practical value in medicine is hydrogen ion determination?

27. Explain osmotic pressure and osmosis.

28. How does ionization affect osmotic pressure?

29. Define, (a) isotonic, (b) hypotonic, (c) hypertonic.

30. What are solutions for infusion?

31. What is a physiological salt solution?

32. Name and explain other solutions used for infusion.

33. Define, (a) molecular solution, (b) ionic solution, (c) colloidal solution.

34. Compare colloidal solutions with true solutions.

35. Give examples of colloids.

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CHAPTER X

PREPARATION OF SOLUTIONS

Weighing and Measuring Drugs.
Kinds of Solutions Made.
Methods of Making Solutions.
Modes of Effecting Solution of Solids.
Rules for Making Calculations.
  Solutions from Pure Drugs.
  Solutions from Stock Solutions and Tablets.
  Solutions from Single Tablets.
Problems.
Formulæ of Solutions in General Use.

The solutions a nurse is called upon to prepare are usually antiseptic or astringent solutions which are to be applied as wet dressings, sprays, douches, gargles, or irrigations to wounds, mucous surfaces, or the skin.

WEIGHING AND MEASURING DRUGS

In the preparation of solutions, weighing and measuring are important operations. Weighing requires the use of a balance or scale. A *balance* is an apparatus used to determine the force of gravity on a substance as compared with the force of gravity on a standard weight. Different types of balances are manufactured, some of which are extremely accurate instruments. To keep a balance in good condition it must receive reasonable treatment.

Before using a balance note whether the pans swing evenly. The indicator should swing an equal distance to each side of the center. Many balances have thumb screws at the ends of the beams, by means of which the pans can be made to swing evenly. The substance to be weighed should not be placed directly upon metallic pans but upon a sheet of glazed paper. This keeps the drug from coming in direct contact with the pan and also facilitates removing the drug from the pan. In weighing it is better to depend upon the uniform swinging of the indicator a little to each side of the zero point rather than to wait until it stops at the zero mark. The balance should be equiped with both metric and apothecaries' weights. In weighing quantities of ten grains or less a balance sensitive to one-thirtieth of a grain should be used. When weighing quantities above ten grains a balance having a sensitiveness of one grain is usually satisfactory.

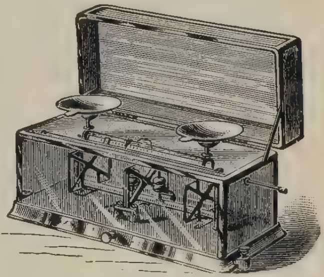
FIG. 24.—Torsion balance.

The measuring of liquids is accomplished with *graduated vessels* or *pipettes*. Graduates of various shapes and sizes are in use. They may be graduated in the metric, apothecaries' or both scales. Glass graduates are either conical, tumbler-shaped or cylindrical in form. Cylindrical graduates are the most accurate because of their uniform small diameter. The tumbler shaped graduates, due to the larger diameter, are least accurate. Small graduates for measuring minims are also in use. When only a few minims are to be measured a *minim pipette*, graduated from 5 to 60 minims, is more accurate than a graduate.

In using a glass graduate it should be held in the left hand so that the upper surface of the liquid is on a level with the eye. The stopper of the bottle, from which the liquid is to be poured, may be held by the third and fourth fingers of the same hand, while the bottle is held by the right hand. The bottle should be held so that the label will not become soiled by any liquid that may run down the side. Due to capillary attraction the surface of the liquid in a graduate is concave and not flat. This concave surface is called the *meniscus*. The reading should be taken at the lowest level of the meniscus. The accurate measuring of liquids is as important as the accurate weighing of dry substances.

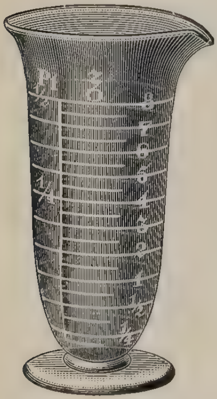

FIG. 25.—Eight-ounce graduate.

KINDS OF SOLUTIONS MADE

Solutions are made from pure drugs, stock solutions, and tablets. Pure drugs are those solid or liquid substances that exist in the pure state. They are 100 per cent in strength. Drugs which exist in crystalline or powder form, such as boric acid, iodine, silver nitrate, gentian violet, carbolic acid, mercuric chloride, and lead acetate, are pure drugs. A few drugs are in liquid form in the pure state, as for example, cresol, alcohol, and glycerin.

Stock solutions are relatively strong solutions of drugs, from which weaker solutions may be made. They have a concentration above that desired for use. It is convenient to have stock solutions of the commonly used drugs on hand so that solutions of desired strength may quickly be made without the inconvenience of weighing the pure drug. Some of the drugs most commonly kept in stock solutions are silver nitrate, potassium permanganate, mercuric chloride, phenol, potassium iodide and magnesium sulphate.

Some drugs are compressed into tablets so that each tablet contains a definite known weight of the drug. Such tablets may be used to make solutions. Using the drug in tablet form avoids the inconvenience of weighing it.

METHODS OF MAKING SOLUTIONS

Solutions are made to be of definite percentage or ratio strength. A 1 per cent solution, for example, must be made so that it will contain 1 part of drug and 99 parts of solvent in 100 parts of solution. A 1:1000 solution must be made so that it will contain 1 part of drug and 999 parts of solvent in 1000 parts of solution.

To make solutions accurately they should be made by weight, that is, a given part by weight of the drug should be dissolved in a given number of parts by weight of the solvent. This is spoken of as the "weight to weight" method and is used by pharmacists. This method is somewhat inconvenient since the temperature and specific gravity of the solvent must be considered in determining its weight.

A more convenient method known as the "weight to volume" method is sufficiently accurate for solutions a nurse is called upon to make. This method gives results which are substantially correct in solutions up to about 10 per cent in strength. In making solutions above this strength this method is less accurate. To make 100 cc. of a 1 per cent solution by this method 1 part by weight of the drug is placed in a graduate and a sufficient amount of solvent added to make 100 cc. of solution.

Greater accuracy is obtained when metric weights and measures are used instead of apothecaries'. This is because a cubic centimeter weighs a gram but in the apothecaries' system a fluidounce does not weigh an ounce or 480 grains but 455 grains.

MODES OF EFFECTING SOLUTION OF SOLIDS

In pharmacy, the usual method of dissolving a solid drug is to reduce it to a fine powder by means of a mortar and pestle and then pouring the solvent into the mortar and triturating until solution results.

In making a large quantity of solution the drug may be ground to a powder in a mortar and then a portion of the solvent added and triturated with the drug. When the solvent becomes saturated it is poured off and a fresh portion of solvent is added. This is repeated until all of the drug has been dissolved.

Hygroscopic or deliquescent substances should not be reduced to a powder before adding the solvent because gummy lumps will be formed, which are difficult to dissolve. The best way to dissolve these substances is to pour them upon the surface of the solvent and stir rapidly with a glass rod.

When the drug is readily soluble in water, as for example, silver nitrate or zinc sulphate, powdering is not necessary but solution may be effected by placing the drug directly into the solvent and stirring it until solution results.

Solutions of solids usually require filtration to remove small particles of insoluble foreign matter such as particles of soot or fragments of cork. This may be done by pouring it through a piece of cotton placed in the neck of a funnel.

Fig. 26.—Triturating mortar.

RULES FOR MAKING CALCULATIONS

Solutions from Pure Drugs.—In making a solution of a given strength from a pure drug it is necessary to calculate the amount of the drug to use to prepare a given quantity of solution. If 100 cc. of a 5 per cent solution of sodium bicarbonate is to be made, the amount of sodium bicarbonate to be used may be calculated by taking 5 per cent of the weight of the solution.

100 cc. weigh 100 Gm.

$$100 \text{ Gm.} \times 5 \text{ per cent} = 100 \times \frac{5}{100} = 5 \text{ Gm.}$$

The solution is made by the "weight to volume" method by placing 5 grams of sodium bicarbonate in a graduate and adding a portion of the solvent and when solution has been effected filling the graduate to the 100 cc. mark. The object of dissolving the drug in a portion of the solvent before filling the graduate to the 100 cc. mark is to allow for the *shrinkage* which occurs when a solid dissolves in a liquid. If the graduate were filled to the 100 cc. mark at once the total amount of solution would be less than 100 cc. after solution had occurred, due to shrinkage of the solute in going into solution. The volume of a solution is always less than the sum of the volumes of the solute and solvent, when the solute is a solid.

The following rule may be stated for making solutions from pure drugs: *Multiply the quantity by the strength of the solution to be prepared.*

Application of Rule

Example: How much silver nitrate is needed to make one fluidounce of a 3 per cent solution?

Accurate Method:

1 fluidounce weighs 455 grains.

$$455 \times \frac{3}{100} = 13\tfrac{13}{20} \text{ grains.}$$

In using this method $13\frac{13}{20}$ grains of silver nitrate are dissolved in an amount of water so that the total amount of solution weighs 455 grains. This gives a solution of correct percentage strength but the total amount of solution is slightly less than a fluidounce.

Convenient Method:

In this method 1 fluidounce is assumed to weigh 480 grains.

$$480 \times \frac{3}{100} = 14\tfrac{2}{5} \text{ grains.}$$

In using this method $14\frac{2}{5}$ grains of silver nitrate are dissolved in a quantity of water so that the total amount of solution measures one fluidounce. This method is substantially correct for the solutions commonly made.

Changing to Metric:

1 fluidounce = 30 grams (approximately)

$$30 \times \frac{3}{100} = 0.9 \text{ gram.}$$

In using this method 0.9 gram of silver nitrate is dissolved in a quantity of water so that the total amount of solution measures one fluidounce. For ordinary practical purposes this method is to be preferred to the preceding methods. The answer is always in grams or fractions of a gram. The drug can readily be weighed in these units. If a problem is solved in the apothecaries' system the answer may be a large number of grains, in which case it would be necessary to change it to drams or ounces before the drug could be weighed.

Example: Make a pint of a 1:1000 solution of potassium permanganate.

1 pint = 7680 minims which may be assumed to weigh 7680 grains.

$$7680 \times \frac{1}{1000} = 7\tfrac{7}{10} \text{ grains.}$$

or, 1 pint = 500 grams

$$500 \times \frac{1}{1000} = 0.5 \text{ gram.}$$

Example: Prepare 5 fluidrams of a 4 per cent solution of zinc sulphate.

5 fluidrams = 60 × 5 = 300 grains

$$300 \times \frac{4}{100} = 12 \text{ grains.}$$

or, 5 fluidrams = 4 × 5 = 20 grams

$$20 \times \frac{4}{100} = 0.8 \text{ gram.}$$

Example: Make 100 cc. of a ½ per cent solution of tannic acid.

$$100 \times \frac{.5}{100} = 0.5 \text{ gram.}$$

Solutions from Stock Solutions and Tablets.—In making a solution from a stock solution it is necessary to calculate the amount of stock solution to use. The "volume to volume" method is used. The amount of stock solution needed is poured into a graduate and the necessary amount of solvent is added to make the amount of solution required.

To make a solution from tablets it is necessary to calculate the number of tablets to use. The tablets are then placed in a graduate and dissolved in a portion of the solvent and then a sufficient amount of solvent is added to make the quantity of solution required.

A common rule may be stated for making solutions from stock solutions and tablets, as follows: *Divide the strength of the desired solution by the strength of the drug on hand (stock sol. or tablet) and multiply by the amount required.*

APPLICATION OF RULE TO STOCK SOLUTIONS

Example: Make 500 cc. of a 1:1000 solution of silver nitrate from a 10 per cent stock solution.

$$\tfrac{1}{1000} \div \tfrac{10}{100} \times 500 = \tfrac{1}{1000} \times \tfrac{100}{10} \times 500 = 5 \text{ cc.}$$

To make the solution 5 cc. of the stock solution is poured into a graduate which is then filled to the 500 cc. mark with water.

Example: Make 8 fluidounces of a ½ per cent solution from a 5 per cent stock solution.

8 fluidounces = 240 cc.

$$\frac{.5}{100} \div \frac{5}{100} \times 240 = \frac{.5}{100} \times \frac{100}{5} \times 240 = 24 \text{ cc.}$$

Application of Rule to Tablets

Example: Prepare 8 fluidounces of a 2 per cent solution of potassium bicarbonate from tablets of 5 grains.

8 fluidounces = 240 cc. 5 grains = $5 \times 0.065 = 0.325$ grams.

$$\frac{2}{100} \div \frac{325}{1000} \times 240 = \frac{2}{100} \times \frac{1000}{325} \times 240 = 14.7 \text{ tablets.}$$

The answer is approximately 15 tablets. This number of tablets is dissolved in a portion of the solvent and then the graduate is filled to the 8 fluidounce mark.

Example: Prepare a pint of a 1:1000 solution from 7½ grain tablets of mercuric chloride.

1 pint = 500 cc. 7½ grains = 0.5 grams.

$$\frac{1}{1000} \div \frac{5}{10} \times 500 = \frac{1}{1000} \times \frac{10}{5} \times 500 = 1 \text{ tablet.}$$

Example: Prepare 200 cc. of a ½ per cent solution of potassium permanganate from 0.2 gram tablets.

$$\frac{.5}{100} \div \frac{2}{10} \times 200 = \frac{.5}{100} \times \frac{10}{2} \times 200 = 5 \text{ tablets}$$

Solutions from Single Tablets.—At times it may be necessary to make a solution of a given strength from a single tablet. In this case it is necessary to calculate the amount of solvent required in which to dissolve the tablet. The rule follows: *Divide the strength of the tablet by the strength of the desired solution.*

Application of Rule

Example: From a 5 grain tablet of sodium bicarbonate prepare a 5 per cent solution.

5 grains = $5 \times 0.065 = 0.325$ grams

$$\frac{325}{1000} \div \frac{5}{100} = \frac{325}{1000} \times \frac{100}{5} = 6.5$$

To make the solution dissolve the tablet in 6.5 cc. of water.

Example: From a 2 gram tablet of sodium chloride prepare a physiological salt solution.

$$2 \div \frac{.85}{100} = 2 \times \frac{100}{.85} = 235$$

To make the solution dissolve the tablet in 235 cc. of water.

PROBLEMS

Solutions from Pure Drugs

1. Calculate the amount of silver nitrate required to make a quart of a 1:1000 solution.

2. How much solute is required to make 4 liters of a ½ per cent solution of mercuric chloride?

3. In making a liter of Physiological Solution of Sodium Chloride, *U.S.P.*, how much salt is needed?

4. The *U.S.P.*, Solution of Potassium Hydroxide contains 5 grams of potassium hydroxide in each 100 cubic centimeters. How much solute is needed to make one pint of this solution?

5. How many grams of potassium permanganate are needed to make a pint of a 1:1000 solution?

6. Calculate the amount of carbolic acid crystals needed to make 8 fluidounces of a 5 per cent solution.

7. How many cubic centimeters of compound Cresol Solution, *U.S.P.* are needed to make a quart of a ½ per cent solution?

8. Determine the amount of solute required to make 5 fluidounces of a saturated solution of potassium permanganate.

9. The *U.S.P.*, Solution of Calcium Hydroxide (lime water) contains 0.14 grams in each 100 cc. How much solute is needed to make a liter of this solution?

10. How much glycerin is needed to make 50 cc. of a 20 per cent solution?

11. In making a saturated solution of boric acid how many grams are needed for a liter of solution?

12. Calculate the amount of acriflavine needed to make a pint of a 1:5000 solution.

13. How many grams of mercurochrome are needed to make 8 fluidounces of a 2 per cent solution?

14. Give the amount of solute needed in making a fluidounce of a 20 per cent solution of mild silver protein.

15. Calculate the amount of ferric chloride needed to make 0.5 of a liter of Solution of Ferric Chloride, *U.S.P.*, which has a concentration of 10 per cent.

16. In making a liter of a 5 per cent lysol solution, calculate the number of cubic centimeters of lysol needed.

17. How much solute is needed to make 500 cubic centimeters of a 5 per cent solution?

18. How would you prepare 6 fluidounces of Solution of Sodium Arsenate, *U.S.P.*, which has a concentration of 1 per cent?

19. The *U.S.P.*, Solution of Zinc Chloride has a strength of 50 per cent. How would you prepare 2 fluidounces of this solution?

20. How many grams of mild silver protein are needed to make 100 cubic centimeters of a 10 per cent solution?

21. How much glucose (dextrose) is required to make a pint of a 15 per cent solution?

22. Calculate the amount of tannic acid needed to make 4 fluidounces of a 0.2 per cent solution.

23. How much gentian violet is needed to make 6 fluidounces of a 1 per cent solution?

24. A saturated solution of picric acid has a strength of 1.2 per cent. How much picric acid is required to make 4 fluidounces of a saturated solution?

25. Determine the amount of alum needed to make 8 fluidounces of a 1½ per cent solution.

Solutions from Stock Solutions

1. How much of a 10 per cent stock solution of silver nitrate is needed to make a pint of a 1:10000 solution?

2. Calculate the number of cubic centimeters of a 6 per cent solution of potassium permanganate required to make a liter of a 1:1000 solution.

3. How would you prepare 250 cubic centimeters of a ½ per cent solution of carbolic acid from a 6 per cent solution?

4. From a 25 per cent solution of sodium chloride prepare 100 cubic centimeters of a physiological salt solution.

5. How much stock solution, 50 per cent in strength, is required to make a quart of a 3 per cent solution?

6. Calculate the amount of liquid phenol (90 per cent) required to make a pint of a 5 per cent phenol solution.

7. How much of a 5 per cent solution of mercuric chloride is needed to make a liter of a 1:3000 solution?

8. How many cubic centimeters of a 10 per cent solution of sodium bicarbonate should be used to make a pint of a 4 per cent solution?

9. From a 10 per cent solution of syrup of rhubarb make 50 cubic centimeters of a 2 per cent solution.

10. Determine the amount of a 1½ per cent creosote solution required to make 6 fluidounces of a 1 per cent solution.

11. How would you prepare a pint of a 70 per cent alcohol solution from 95 per cent alcohol?

12. Calculate the number of cubic centimeters of a 50 per cent magnesium sulphate solution required to make 8 fluidounces of a 20 per cent solution.

13. Make 200 cubic centimeters of a 1 per cent solution of zinc sulphate from a 10 per cent solution.

14. How would you prepare 2 fluidounces of a 2 per cent solution from a 25 per cent solution of strong silver protein?

15. From a 5 per cent lysol solution make 1500 cubic centimeters of a ½ per cent solution.

16. Determine the amount of a 10 per cent solution of sodium citrate required to make 50 cubic centimeters of a 2½ per cent solution.

17. How much of a 50 per cent solution of tannic acid is required to make a pint of a 5 per cent solution?

18. How would you make a quart of a 2 per cent solution from a 10 per cent tincture of green soap?

19. Prepare one ounce of a 0.2 per cent solution of potassium carbonate from a 2 per cent solution.

20. How much Glycerite of Tannic Acid, *U.S.P.*, (20 per cent) is needed to make 25 cubic centimeters of a 3 per cent solution?

21. Calculate how to prepare 50 cc. of a 1½ per cent alum solution from a 5 per cent stock solution.

22. From a 2 per cent solution of strong silver protein make 30 cubic centimeters of a 0.5 per cent solution.

23. How would you make 200 cubic centimeters of a 1 per cent solution of gentian violet from a 3 per cent stock solution?

24. How much of a 2 per cent acriflavine solution is needed to make 250 cubic centimeters of a 1:5000 solution?

25. Make one fluid ounce of a ½ per cent mercurochrome solution from a 2 per cent solution.

SOLUTIONS FROM TABLETS

1. How many 7½ grain tablets of mercuric chloride are required to make a quart of a 1:1000 solution?

2. How would you prepare 8 fluidounces of a 5 per cent solution of boric acid from 5 grain tablets?

3. Calculate the number of tablets needed to make 2 fluidrams of a 4 per cent solution of potassium chlorate from 0.3 gram tablets.

4. How many 10 grain tablets of sodium bicarbonate are needed to make a pint of a 3 per cent solution?

5. How would you prepare 250 cubic centimeters of a 1:1000 solution of potassium permanganate from tablets of 0.2 gram?

6. Calculate the number of 10 grain tablets of calcium lactate required to make 100 cubic centimeters of a 5 per cent solution.

7. Determine the number of tablets needed to make 8 fluidounces of a 50 per cent solution of potassium iodide from 5 gram tablets.

8. How many 3 grain tablets of ammonium chloride are needed to make 4 fluidrams of a 3 per cent solution?

9. Calculate the number of 2 grain tablets of procaine hydrochloride required to prepare 10 cubic centimeters of a 2 per cent solution.

10. How would you prepare a pint of a 2 per cent chloramine solution from tablets of 5 grains?

Solutions from Single Tablets

1. How would you prepare a 1:1000 solution of potassium permanganate from a 3 grain tablet?

2. In how much water should a 10 grain tablet of sodium bicarbonate be dissolved to make a 5 per cent solution?

3. Determine the amount of water needed to dissolve a 7½ grain tablet of mercuric chloride to make a 1:1000 solution.

4. How much water is needed to make a physiological salt solution from a 2 gram tablet of sodium chloride?

5. How would you prepare a 10 per cent solution of sodium cacodylate from a 5 grain tablet?

FORMULÆ OF SOLUTIONS IN GENERAL USE

Burow's Solution, *N.F.*

Lead Acetate	150 Gm.
Aluminum Sulphate	85 Gm.
Water to make	1000 cc.

Note: The resulting solution contains aluminum acetate.

Uses: Used in 1 to 5 per cent dilution as astringent and antiseptic mouth wash and gargle.

Compound Solution of Cresol, *U.S.P.*

Cresol	500 cc.
Linseed Oil	350 cc.
Potassium Hydroxide	14.5 Gm.
Sodium Hydroxide	39 Gm.
Water to make	1000 cc.

Uses: A valuable disinfectant for surgical purposes, used in ¼ to 2 per cent solutions

1 gr.

COMMERCIAL CRESOL PREPARATIONS

Lysol—a solution of cresols in potash soap and alcohol.

Creolin—an emulsion of cresols in rosin soap.

Krelos—a solution of cresols in rosin soap.

Phenoco—a soap solution of coal-tar creosote and higher phenol homologues.

COAL TAR SOLUTION, *N.F.*

Coal Tar	200 Gm.
Quillaja	100 Gm.
Alcohol, to make	1000 cc.

Uses: Antiseptic and stimulant in chronic skin diseases.

COMPOUND MENTHOL SPRAY, *N.F.*

Menthol	1.0 Gm.
Camphor	1.0 Gm.
Methyl Salicylate	0.5 cc.
Eucalyptol	0.2 cc.
Oil of Cinnamon	0.2 cc.
Liquid Petrolatum, to make	100.0 cc.

Uses: Antiseptic inhalent.

DOBELL'S SOLUTION, *N.F.*

Sodium Borate	15 Gm.
Sodium Bicarbonate	15 Gm.
Liquefied Phenol	3 cc.
Glycerin	35 cc.
Water to make	1000 cc.

Directions: Dissolve the first two ingredients in about 500 cubic centimeters of water and add the glycerin and liquefied phenol. After standing about half an hour or until effervescence has stopped add sufficient water to make 1000 cubic centimeters and filter through cotton.

Uses: This solution is used as a nasal wash or spray.

EUCALYPTOL SPRAY, *N.F.*

Eucalyptol	5 cc.
Liquid Petrolatum	95 cc.

Uses: Antiseptic inhalent.

GLYCERITE OF BOROGLYCERIN, *U.S.P.*

Boric Acid	310 Gm.
Glycerin, to make	1000 Gm.

Directions: The glycerin is heated in a tared porcelain dish on a sand bath to 150°C. and the boric acid is added in small quantities. Constant stirring is necessary until all of the boric acid has been added. The heating is continued with frequent stirring until the mixture has been reduced to 500 grams. The solution is then made up to 1000 grams by adding 500 grams of glycerin.

Note: When boric acid and glycerin are heated in the above proportions, *boroglycerin* ($C_3H_5BO_3$) is formed.

Uses: Mild antiseptic. To be diluted 10 times before use.

GLYCERITE OF TANNIC ACID, *U.S.P.*

Tannic Acid	20 Gm.
Sodium Citrate	1 Gm.
Glycerin	79 Gm.

Uses: General astringent, especially valuable for use in mouth and throat.

HARRINGTON'S SOLUTION

Mercuric Chloride	0.8 Gm.
Hydrochloric Acid	60.0 Gm.
Distilled Water	300.0 Gm.
Alcohol	640.0 Gm.

Uses: Used to disinfect the hands and skin in surgery.

LABARRAQUE'S SOLUTION, *U.S.P.*

Sodium Carbonate, Monohydrated	70 Gm.
Chlorinated Lime	100 Gm.
Water, to make	1000 Gm.

Note: This solution must be made according to directions given in the U.S.P. Chemical action takes place in making this solution and sodium hypochlorite is formed.

Uses: For disinfecting bed pans and other utensils. Also as a mouth wash and gargle (5 per cent).

PHENOLATED SOLUTION OF IODINE, *N.F.*

(Boulton's Solution)

Lugol's Solution	15 cc.
Liquid Phenol	6 cc.
Glycerin	165 cc.
Water, to make	1000 cc.

Uses: Application to wounds.

Solution of Lead Subacetate, *U.S.P.*

(Goulard's Extract)

Lead Acetate	220 Gm.
Lead Monoxide	140 Gm.
Distilled Water, to make	1000 cc.

Uses: Used as an external sedative and astringent in bruises and sprains.

Solution of Zinc Chloride, *U.S.P.*

Zinc, granulated	240 Gm.
Hydrochloric Acid	840 Gm.
Nitric Acid	12 Gm.
Precipitated Zinc Carbonate	12 Gm.
Distilled Water, to make	1000 cc.

Uses: Used as an astringent and antiseptic.

Soft Soap, *U.S.P.* (Green Soap, So-called)

Linseed Oil	400 Gm.
Potassium Hydroxide	19 Gm.
Sodium Hydroxide	49 Gm.
Glycerin	50 cc.
Water, to make	1000 cc.

Uses: Used in the preparation of the skin in surgery.

Tincture of Green Soap, *U.S.P.*

Soft Soap	650 Gm.
Oil of Lavender	20 cc.
Alcohol, to make	1000 cc.

Uses: Used in cleaning the skin before an operation and for washing the surgeon's hands.

Thiersch's Solution

Boric Acid	12 Gm.
Salicylic Acid	2 Gm.
Water, to make	1000 cc.

Uses: For washing mucous membrane cavities as bladder, nose, and mouth.

Thymol Spray, *N.F.*

Thymol	1 Gm.
Liquid Petrolatum	100 cc.

Uses: Antiseptic inhalant.

TINCTURE OF IODINE, *U.S.P.*

Iodine	70 Gm.
Potassium Iodide	50 Gm.
Distilled Water	50 cc.
Alcohol, to make	1000 cc.

Uses: To sterilize the skin before operations and for disinfecting wounds.

CHURCHILL'S TINCTURE OF IODINE, *N.F.*

Iodine	165 Gm.
Potassium Iodide	35 Gm.
Water	250 cc.
Alcohol, to make	1000 cc.

Uses: Similar to tincture of iodine although it has double the strength.

QUESTIONS FOR CLASS DISCUSSION

1. What kinds of solutions is a nurse called upon to make?
2. What is a balance?
3. Give the proper way of handling a balance so that it will weigh accurately.
4. How are liquids measured?
5. Explain the proper way of holding a graduate when measuring liquids.
6. What is the meniscus?
7. From what kinds of drug preparations are solutions made?
8. What is a pure drug?
9. What is a stock solution?
10. What is meant by a 1 per cent solution? A 1:1000 solution?
11. Compare the "weight to weight" method with the "weight to volume" method of making solutions. Which is the more accurate? The more convenient?
12. What methods may be used to facilitate the solution of solids?
13. State the rule for making a solution from a pure drug.
14. State the rule for making solutions from stock solutions and tablets.
15. State the rule for making a solution from a single tablet.

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CHAPTER XI

ANTISEPTICS AND DISINFECTANTS

- General Considerations.
- Mode of Action.
- Chemical Agents.
  - Salts of Heavy Metals.
  - Chlorine and Iodine Group.
  - Phenol Group.
  - Anilin Dyes.
  - Oxidizing Agents.
  - Volatile Oils.
  - Miscellaneous Agents.
- Physical Agents.
- Disinfection of Infected Articles.
  - Body Discharges.
  - Utensils and Instruments.
  - Cloth Materials.
  - Terminal Disinfection of Rooms.
- Therapeutic Applications.
  - Skin Disinfection.
  - Mucous Membranes.
  - Wound Disinfection.
  - Systemic Infections.

GENERAL CONSIDERATION

When infection exists in body tissues or when organic matter undergoes decomposition due to bacteria, the term *septic* may be used to designate such conditions. The term *aseptic* means freedom from infection or putrefaction and is usually used to refer to freedom from harmful bacteria. The word *antiseptic* literally means against a septic condition. An antiseptic may be defined as an agent which hinders the development of microorganisms without necessarily killing them. A *disinfectant* is a substance which kills infecting agents.

It is not always possible to distinguish between an antiseptic and a disinfectant. A chemical agent may exert an antiseptic action against a certain kind of microorganism while its action against another kind may be that of a disinfectant. The term *bactericide* is sometimes used to refer to agents which are destructive to bacteria, while the term *germicide* is applied to substances which kill microörganisms of all kinds. There is no practical difference between a bactericide and a germicide since an agent which is destructive to bacterial spores will kill all other forms of microorganisms. All bactericides, therefore, are germicides. The terms, antiseptic, disinfectant, and germicide are generally used indiscriminately. Antiseptic agents used to absorb or destroy objectionable odors are known as *deodorants*.

MODE OF ACTION

The destruction of bacteria by chemical agents is due chiefly to chemical reactions which occur between the chemicals and the protoplasm of the bacterial cells. Some disinfectants, such as phenol, kill bacteria by coagulating the protein of their protoplasm; others combine chemically with certain constituents of the bacterial protoplasm. In disinfectants of the heavy metal group, the degree of ionization is an important factor. The metallic ions combine with the protein of the bacterial cell and cause its death. Some chemicals act as oxidizing agents in that they liberate nascent oxygen which combines chemically with the constituents of the cells. Hydrogen peroxide and potassium permanganate are examples of this type of action.

The presence of water is necessary to bring about the penetration of the chemical into the cell. Phenol, for example, is not very effective when dissolved in oil but in an aqueous solution it is a powerful disinfectant.

A chemical in pure or dry form has little effect upon bacteria. Absolute alcohol, for example, has little effect upon bacteria, while a 60 to 70 per cent aqueous solution is an effective germicide. The action of most antiseptics is diminished in the presence of sputum, blood, or other organic substances, which act as absorbing agents.

The destruction of bacteria is not brought about instantly but requires a certain period of time, varying with the agent used, its concentration and the substance on which it is acting. Some antiseptics have a *selective action* against certain bacteria. Gentian violet, for example, is very effective against staphylococcus but only feeble in its action against the colon bacillus.

CHEMICAL AGENTS USED

2 mercury

Salts of the Heavy Metals

Mercuric Chloride [$HgCl_2$], *U.S.P.*, also known as bichloride of mercury or corrosive sublimate, is a very effective germicide. It occurs as colorless crystals but is usually sold in the form of tablets in which the mercuric chloride is mixed with sodium chloride or ammonium chloride, to render it more readily soluble. Tablets of this type are described in the pharmacopœia under the name Poison Tablets of Corrosive Mercuric Chloride. They are colored blue, are angular in shape and have the word "poison" and the skull and cross bones design stamped upon them. These precautions are taken to prevent the careless use of these tablets for mercuric chloride is very poisonous. Each tablet contains 0.5 of a gram (gr. viiss) of mercuric chloride.

In aqueous solution mercuric chloride ionizes and its germicidal activity depends upon the concentration of mercury ions which readily combine with protoplasm, forming an insoluble albuminate of mercury. The practical usefulness of mercuric chloride is limited because, (1) it is a powerful internal poison, (2) it corrodes metals and, (3) in the presence of organic matter the mercury ions form inert compounds which decreases its efficiency.

It is usually used in 1:1000 solution which may be made by dissolving a 7½ grain tablet in a pint of water (0.5 L.). Distilled water should be used in making the solution as the mineral matter in tap water tends to precipitate the mercuric chloride. This solution is of sufficient strength to kill all harmful bacteria if exposed to it for a half hour. On mucous membranes or wounds it is used in concentration of 1:20,000 to 1:2000.

Mercuric chloride is a good disinfectant for the hands of surgeons and nurses. It is not well suited for sputum or other excreta because it combines with the organic matter they contain. Because it is very poisonous it must be used with caution on mucous surfaces and wounds and should not be used for the disinfection of eating utensils. It is irritating to the skin if used in high concentration or too frequently. Since it corrodes metals it should not be used for the disinfection of instruments.

Mercurochrome [$C_{20}H_7Br_2(HgOH)O_5Na_2$] is a complex compound of mercury and a dye. It contains 23 to 24 per cent of mercury and occurs as iridescent green scales. It does not precipitate protein and penetrates the skin and mucous membranes readily.

It does not yield mercury ions and is comparatively free from irritating action. Mercurochrome is used in 1 to 2.5 per cent solutions in the treatment of infections of the bladder, wounds, skin, and mucous membrane of the eye. It stains the skin and fabrics. The stain may be removed by a 2 per cent potassium permanganate solution followed by a 2 per cent solution of oxalic acid.

Other mercuric compounds used as antiseptics are metaphen, meroxyl, mercurol, mercurophen, mercuric cyanide, mercury oxycyanide, and mercuric benzoate.

Silver Nitrate [$AgNO_3$], *U.S.P.*, occurs as colorless crystals which turn gray or grayish black on exposure to light. In aqueous solution it ionizes and possesses high germicidal efficiency. It forms compounds with proteins but this does not destroy its efficiency since these compounds are soluble and liberate small quantities of silver ions. Silver nitrate is used on inflamed mucous membranes and ulcerated surfaces. A solution of 1:1000 is destructive to most bacteria in a very short time. A 1:10,000 solution is used for irrigating the urethra in gonorrhea. A 2 per cent solution is used in the eyes of new-born infants to prevent the development of *ophthalmia neonatorum.*

Colloidal Silver Preparations consisting of silver combined with protein are valuable antiseptics. They do not precipitate proteins and are, therefore, not astringent and relatively non-irritating. The germicidal effect of colloidal silver preparations is due to the gradual liberation of silver ions. *Mild Silver Protein, U.S.P.*, (Mild Protargin) is a colloidal silver preparation which occurs as dark brown scales or granules and contains between 19 and 25 per cent of silver. It is freely soluble in water but only a small portion of the silver ionizes in solution. It is used in 10 to 40 per cent solutions chiefly on mucous membranes. Preparations of this type are marketed under the names of argyrol, argyn, cargentos, silvol, solargentum, and vargol.

Strong Silver Protein, U.S.P., (Strong Protargin) is another colloidal silver preparation which occurs as a brown powder and contains about 8 per cent of silver. Although it contains less silver than mild protargin it is stronger in therapeutic action due to the fact that in solution it is more highly ionized. It is used in 0.1 to 10 per cent solutions. Preparations of this type are marketed under the names of protargol, proganol and protargentum.

Chlorine and Iodine Group

Chlorine and iodine are powerful germicides. Aqueous solutions of chlorine liberate nascent chlorine which, due to its affinity for hydrogen, combines readily with water and liberates nascent oxygen. Nascent oxygen is a powerful oxidizing agent. The antiseptic action of chlorine, however, is due not alone to the nascent oxygen liberated but also to the action of chlorine on the protoplasm of the bacterial cell. One part of nascent chlorine in 1,000,000 parts of water will kill most pathogenic bacteria in a few minutes.

Chlorinated Lime, *U.S.P.*, is a white or grayish white powder made by the action of chlorine upon calcium hydroxide (slaked lime). It consists chiefly of calcium hypochlorite and calcium chloride, and has a strong odor of chlorine. It is a cheap, powerful disinfectant and may be used in solution or as the dry powder. Its chief use is to disinfect infected materials, such as feces and other excreta. Due to its irritant effect it is not suited to application to tissues. Chlorinated lime is a strong bleaching agent and must not be used on colored fabrics. It has a corrosive action on metals.

A solution of six ounces of chlorinated lime to a gallon of water makes a satisfactory disinfectant for feces. A quart of this solution is added to each discharge and allowed to stand for an hour. This solution is also a satisfactory disinfectant for use in scrubbing floors and walls. Chlorinated lime is used in making *Labarraque's Solution, U.S.P.*, by dissolving it in a solution of monohydrated sodium carbonate. This solution is used for the disinfection of toilets, sinks and glassware.

Surgical Solution of Chlorinated Soda, *U.S.P.*, (Modified Dakin's Solution) commonly called Dakin's solution, is an aqueous solution of chlorine compounds of sodium made from chlorinated lime and exsiccated sodium phosphate. Its strength must be accurately adjusted so that the available chlorine is between 0.43 and 0.48 per cent. If it is less than 0.43 per cent it is without antiseptic value and if greater than 0.48 per cent it is irritating to wounds. It's alkalinity must be adjusted according to directions given in the pharmacopœia. The solution is used in full strength. It deteriorates rapidly and must be kept in a cool place protected from light. It must not be kept longer than seven days.

This solution is an efficient antiseptic for infected wounds and is applied by the continuous irrigation method. It promotes healing and is practically non-irritating to wounds but is irritating to the skin which must be protected by petrolatum. Dakin's solution dissolves pus, dead tissue and blood clots and thus has a cleansing effect in wounds.

Chloramine [$C_6H_4(CH_3)(SO_2NNaCl)3H_2O$], *U.S.P.*, chemically is sodium para-toluene sulphonchloramide and occurs as white or slightly yellow crystals. It is also known as "chloramine-T." It is soluble in water and has greater stability than Dakin's solution. In the presence of much blood it is more effective than Dakin's solution. Chloramine is usually employed in 0.1 to 4 per cent solutions. For the treatment of wounds it is used in 1 to 2 per cent strength and applied by the continuous irrigation method.

Dichloramine [$C_6H_4(CH_3)(SO_2NCl_2)$], *U.S.P.*, is also known as "dichloramine-T." Chemically it is toluene parasulphondichloramide. It is practically insoluble in water but soluble in eucalyptol and paraffin. Dichloramine has greater germicidal power than chloramine but has less solvent action on necrotic tissue. In solution the drug is liberated slowly so that a continuous antiseptic action is produced until all of the drug has been used up. It is of value in treating infected wounds, as a spray in the nose and throat, and in making surgical dressings. It is usually employed in 0.5 to 10 per cent strength. In wounds it is used in 5 per cent strength, on mucous membranes $\frac{1}{2}$ to 2 per cent, and in surgery 2 to 10 per cent.

✓ **Iodine** [I], *U.S.P.*, is a non-metallic element occurring as heavy bluish-black crystals having a metallic luster. It is an effective germicide for disinfecting wounds and for preparing the skin for operations. Iodine is used in 3 to 5 per cent alcoholic solutions and also in the forms of tincture of iodine and Lugol's solution. Tincture of iodine is an alcoholic solution of iodine (7 per cent) and potassium iodide (5 per cent), while Lugol's solution is an aqueous solution containing 5 per cent of iodine and 10 per cent of potassium iodide. Iodine is not soluble in water but freely soluble in an aqueous solution of potassium iodide.

Iodine stains the skin brown. The stains are removed by a warm concentrated solution of thiosulphate or by ammonia water. The National Formulary contains a decolorized iodine preparation known as tincture of iodides which contains iodine in the form of ammonium iodide. It has very little germicidal value.

✓ **Iodoform** [CHI_3], *U.S.P.*, occurs as lemon-yellow powder or crystals containing about 97 per cent of iodine. It has a peculiar penetrating odor. Iodoform is made by treating alcohol with iodine in the presence of an alkali. It is nearly insoluble in water and is used as a dusting powder in the treatment of ulcers, wounds, and in surgery as an antiseptic wound dressing. In contact with tissues it slowly liberates iodine which produces its antiseptic effect. It stimulates granulation in wound tissue and thus promotes healing. Systemic poisoning may occur when it is applied to large open wounds or confined cavities, due to absorption of iodine.

Thymol Iodide [$C_{20}H_{24}O_2I_2$], *U.S.P.*, also known as aristol occurs as a reddish-brown powder and contains about 45 per cent of iodine. It is employed chiefly as a dusting powder as a non-toxic substitute for iodoform but is less effective.

6 phenol

PHENOL GROUP

Phenol [C_6H_5OH], *U.S.P.*, commonly called carbolic acid, occurs as colorless, interlaced, needle-shaped, crystals having a peculiar aromatic odor. It is not an acid in the chemical sense, but an alcohol. Phenol melts when heated and can be liquefied by the addition of 10 per cent of water. It is then known as *liquefied phenol* which is an official preparation. It is in this form in which phenol is usually sold by druggists. Phenol is peculiar in that if more than 10 per cent of water is added it becomes cloudy and remains cloudy until 93 per cent or more of water has been added when the water dissolves the phenol. A saturated solution has a concentration of 6.5 per cent.

Glycerite of Phenol, *U.S.P.*, is liquified phenol diluted with an equal volume of glycerin. This solution is miscible with water in all proportions. It is used in making antiseptic solutions of phenol. In making solutions from the crystals hot water should be used as they dissolve very slowly.

Phenol is used in concentrations of 2.5 to 5 per cent. A 5 per cent solution may be used to disinfect excreta, clothing, utensils, instruments, and floors. Phenol is not destructive to fabrics, colors, or metals. It may be used to disinfect the hands of the nurse by washing them for three minutes in a 2½ per cent solution. This should be followed by washing the hands in alcohol to relieve the benumbing effect of phenol. Phenol is irritating and penetrates tissues rapidly and deeply. It precipitates protein but does not combine chemically with it and therefore this does not hinder its penetrating power. It is toxic and not safe to use on large absorbing surfaces due to danger of absorption into the blood stream. Phenol burns on the skin may be treated with alcohol, ether, glycerin, or fixed oils.

Phenol is often used as a standard for the measurement of the efficiency of other disinfectants. The "phenol coefficient" is the ratio of the germicidal power of a disinfectant to that of phenol. A disinfectant having, for example, two times the efficiency of phenol has a phenol coefficient of two. This method of comparison is of value only for the disinfectants related to phenol.

Cresol [$C_6H_4(CH_3)OH$], *U.S.P.*, is a colorless or yellowish brown liquid having a phenol-like odor. It is a mixture of three cresols, namely, metacresol, orthocresol, and paracresol. Cresol has a phenol coefficient varying from two to three and resembles phenol in its germicidal properties. It is not readily soluble in water but is soluble in liquid soap.

Compound Solution of Cresol, *U.S.P.*, is a 50 per cent solution of cresol in linseed oil soap. It may be diluted with water and is used in a ½ to 1 per cent solution for cleaning the hands and in a 3 to 5 per cent solution for disinfecting body excretions. Preparations similar to compound solution of cresol are marketed under the names of lysol, creolin, krelos, cresolin and phenoco.

Picric Acid $[C_6H_2(NO_2)_3OH]$, *U.S.P.*, is chemically known as trinitrophenol and occurs as pale yellow crystals. It is very explosive and is usually mixed with 20 per cent of water for safety in transportation. It has a phenol coefficient of six. Picric acid is used in a saturated aqueous solution (1.2 per cent) as a dressing for burns and superficial wounds. It exerts an anesthetic as well as antiseptic action and has a stimulating action on the growth of new epithelium. A 6 per cent alcoholic solution is used in preparing the skin for a surgical operation. The stain, which it leaves on the skin, may be removed by applying potassium sulphate and then washing with soap and water.

Resorcinol $[C_6H_4(OH)_2]$, *U.S.P.*, occurs as colorless needle-shaped crystals or powder. It resembles phenol in its action but is less powerful. It is used in 10 to 20 per cent solutions as an antiseptic in certain skin diseases.

Leave to dry

COAL TAR DYES

Acriflavine, *N.N.R.*, is derived from acridine which is a constituent of coal tar and the base for a number of dyes. Acriflavine is a brownish-red crystalline powder known chemically as diaminomethylacridine chloride hydrochloride. It is a powerful germicide and the action is not weakened in the presence of blood-serum or wound secretions. It is not toxic and is used in the treatment of wounds and infections of mucous membranes. It is particularly effective against the gonococcus. The strength used is from 1:4000 to 1:1000 in physiological salt solution. Neutral acriflavine is acriflavine from which the molecule of hydrochloric acid has been removed. It is not irritating.

Gentian Violet, *N.N.R.*, occurs as a dark green powder. It penetrates tissues well and possesses selective action against Gram-positive bacteria particularly the staphylococcus and diphtheria bacillus, but is not very effective against Gram-negative bacteria. Gentian violet is not irritating and is comparatively harmless to human tissues. It is sometimes used intravenously in infections caused by Gram-positive organisms, especially the staphylococcus. The strength used is from 1:10,000 to 1:500.

Oxidizing Agents

Solution of Hydrogen Peroxide, *U.S.P.*, is an aqueous solution containing 3 per cent by weight of H_2O_2. The germicidal action is due to the fact that in contact with organic matter it liberates nascent oxygen. It decomposes readily into oxygen and water. Deterioration may be retarded by keeping it in a cool place protected from light and by replacing the stopper of the bottle with a cotton plug. To increase the stability of the solution a small amount of acetanilid may be added to it.

The action of hydrogen peroxide is brief lasting only as long as oxygen is being evolved. It does not penetrate and, therefore, the action is only on the surface. When applied to a suppurating wound the rapid liberation of oxygen which occurs causes an effervescence which serves to clean the wound of pus and blood clots. It is not a powerful germicide but is useful in the preliminary cleansing of infected wounds, foul ulcers, and abscess cavities. It is also used as a mouth wash. The solution is usually diluted with 1 to 3 parts of water before it is used.

Potassium Permanganate [$KMnO_4$], *U.S.P.*, occurs as dark purple crystals of a blue metallic luster. When the crystals or a solution of potassium permanganate are brought in contact with substances which oxidize easily it may explode. It should be kept in glass stoppered bottles to prevent fragments of cork from falling into it and causing explosion. In contact with organic matter it decomposes and liberates oxygen. The following reaction occurs: $4KMnO_4 + 2H_2O = 4MnO_2 + 4KOH + 3O_2$.

Potassium permanganate is a deodorant as well as a germicide and is used as a detergent wash in diseases in which offensive discharges occur. It is irritating and the action is superficial. It is usually employed in 1:4000 to 1:1000 aqueous solutions. As a hand disinfectant it may be used in 1 to 3 per cent solutions. The stain may be removed with oxalic acid.

Volatile Oils

Many of the volatile oils possess antiseptic properties. They are used in the treatment of nasal and throat infections, and as mouth washes. Those most largely used are oil of peppermint, thyme, and eucalyptus. The active principles of these oils are menthol, thymol, and eucalyptol respectively. The antiseptic properties of volatile oils are due chiefly to the phenols and terpenes which they contain.

Thymol [$C_{10}H_{14}O$], *U.S.P.*, is obtained from the oil of thyme and other volatile oils. It occurs as large colorless crystals having the odor of thyme. It is used as a deodorant mouth wash and gargle. A saturated aqueous solution (0.3 per cent) is generally employed.

Menthol [$C_{10}H_{19}OH$], *U.S.P.*, is obtained from oil of peppermint and other mint oils. It is a secondary alcohol (stearoptene) and occurs as colorless crystals having the odor of mint. It is used in 1 to 5 per cent solutions chiefly in combination with other antiseptics for spraying the nasal passages.

Eucalyptol [$C_{10}H_{18}O$], *U.S.P.*, is a colorless aromatic liquid obtained chiefly from oil of eucalyptus. It is used in 3 to 5 per cent solution in liquid petrolatum as a spray in inflammations of the nose and throat.

Miscellaneous Agents

Boric Acid [H_3BO_3], *U.S.P.*, also known as boracic acid occurs as colorless crystals or as a white powder. It is made by decomposing sodium borate (borax), which is found native in California, with hydrochloric or sulphuric acid. Boric acid is not a disinfectant but a mild, non-irritating and soothing antiseptic that reduces the virulence of the bacteria with which it comes in contact. When applied to the skin in saturated solutions it is absorbed in appreciable quantities. It is of value in the treatment of skin affections in which there is pus formation and in diseases of the nose, throat, and eyes. Boric acid is sometimes used in the form of hot dressings and in surgery as a dusting powder.

Solutions are best made with hot water since it is but slowly soluble in cold water. A saturated aqueous solution (approximately 5 per cent) is frequently used. *Antiseptic Solution, N.F.*, is a 2 per cent boric acid solution containing volatile oils and 25 per cent alcohol. Listerine has a similar composition. Thiersch's solution is a weak solution of boric acid containing salicylic acid. *Glycerite of Boroglycerin, U.S.P.*, is a solution of boroglycerin ($C_3H_5BO_3$, boric acid combined with glycerin) in glycerin.

Alcohol [C_2H_5OH], *U.S.P.*, is a colorless, volatile, inflammable liquid having a characteristic odor and a burning taste. It contains 94.9 per cent by volume of absolute ethyl alcohol (grain alcohol). It is also known as ethanol. Alcohol is an effective germicide in a concentration of 60 to 70 per cent. Below 60 and above 80 per cent it is not very effective. Alcohol precipitates albuminous matter and should, therefore, not be used for disinfecting substances with a high protein content. It is generally used as a skin disinfectant.

Soaps are produced by the action of sodium or potassium hydroxide on oils or fats. They are of two kinds, hard and soft. Hard soap is made with sodium hydroxide while potassium hydroxide is used in soft soap. The official hard soap, commonly called castile soap, is made from olive oil and sodium hydroxide, while the official soft soap is made from linseed oil, potassium and sodium hydroxide, and glycerin. *Liniment of Soft Soap, U.S.P.*, is an alcoholic solution of soft soap containing oil of lavender. It is also known as tincture of green soap. Green soap is a soft soap made with potassium hydroxide and a green fixed oil.

The fatty acids formed by the splitting of the alkali salts give soaps a disinfecting action. Soft soap is used in the treatment of skin diseases, chiefly eczema, and as a cleansing agent in surgery. Although soaps are destructive to many kinds of microorganisms they cannot be relied upon to kill all bacteria. Scrubbing the hands thoroughly with soap and warm water will accomplish much in removing bacteria as well as dirt.

Lime [CaO,] *U.S.P.*, also known as quicklime, occurs as a white powder or hard white masses. When water is added to it it evolves heat and is converted into calcium hydroxide (slaked lime). Lime must be kept in well-closed containers or it will absorb moisture from the air and become "air slaked." Air slaked lime is without disinfectant action. Lime is an efficient disinfectant for feces, urine, and sputum. An equal quantity of lime should be mixed with the excreta and permitted to act for an hour.

Milk of lime is a thick mixture of lime and water made by mixing lime with four times its volume of water. Chemically it is calcium hydroxide and undissolved particles of lime in suspension. It should be freshly prepared and used or bottled and protected from air if it is not to be used at once. It is suitable for disinfecting excreta and should be added in equal volume and permitted to act for two hours.

Balsams are oleoresins containing benzoic and cinnamic acids. **Balsam of Peru** *U.S.P.*, is the balsam most commonly used. It is a dark brown viscid liquid and is used as a stimulant antiseptic dressing in wounds, ulcers, and chronic inflammations of the skin and mucous membranes.

Formaldehyde Solution, *U.S.P.*, also known as formalin, is an aqueous solution containing 37 per cent by weight of formaldehyde gas [HCHO]. It is a strong germicide with considerable penetrating power, is not corrosive, and not retarded in its action by albuminous matter. It is suitable for the disinfection of urine, feces, and sputum. It is also a deodorant. An equal volume of a 10 per cent dilution of the commercial solution should be used and permitted to act for one hour. Soiled sheeting and clothing may be immersed in a 5 per cent solution for one hour. Because of irritating fumes liberated by formaldehyde solution it must not be used on the body nor in the sick room.

PHYSICAL AGENTS

dishes, bed linen, feces

In addition to chemical substances, certain physical agencies may be used for the destruction of micro-organisms. *Burning* is a most effective method when practicable. Sputum and other materials collected on cloths are most conveniently disposed of by burning. *Boiling* for ten minutes is a suitable method of disinfecting bedding and clothing. *Dry heat* at 160°C. will kill all bacteria in one hour. *Steam* under pressure used in an apparatus known as an autoclave is used in the sterilization of dressings. *Sunlight* is a highly effective agent in the destruction of bacteria. The germicidal effect of sunlight is due chiefly to the ultra-violet rays.

DISINFECTION OF INFECTED ARTICLES

Body Discharges.—In many diseases the causative organisms leave the body of the host in the body discharges. To prevent the spread of disease the safe disposal of these discharges is important. Discharges from the eyes, ears, nose, mouth, and skin lesions may be collected on cloth or cotton and burned.

Bowel discharges, in diseases such as typhoid fever, cholera infantum, and dysentery, should be disinfected. This may be done by adding five tablespoonfuls of *chlorinated lime* to a liquid stool. It should be thoroughly mixed with the stool and allowed to stand for an hour before being poured into the sewer. If the stool is solid a pint of water should be added before adding the chlorinated lime. Urine may be disinfected by adding three tablespoonfuls of chlorinated lime to each passage. In place of chlorinated lime an equal volume of *milk of lime* or 10 per cent *formalin* solution may be used for the disinfection of bowel and bladder discharges.

Utensils and Instruments.—Utensils, such as dishes, glassware, knives, forks and spoons, that have been used by the patient may be disinfected by being boiled, by being placed in the utensil sterilizer, or by immersing in 5 per cent *phenol* or 2 per cent *formalin* solution for one hour. Thermometers may be kept in a 5 to 10 per cent solution of formalin or a 5 per cent phenol solution for one hour. Surgical instruments are usually boiled in a 5 per cent solution of *sodium carbonate.* Mercuric chloride must not be used on metal instruments since it corrodes metals.

Cloth Materials.—Bed sheets, pillow slips, towels, wash-cloths or clothing of any kind that has been in contact with the patient may be disinfected by boiling with soap and water or immersed for two hours in 5 per cent *phenol* or *cresol* solution and then boiled in water. Another method is to place them in the *autoclave* at a temperature of 120°C. for twenty minutes. Rugs and mattresses may be exposed to the *sunlight* for several hours. It is a good practice to expose material from the sick room to the sunlight as much as possible. The rays of light must not pass through glass, however, since ultra-violet rays are filtered out by glass.

Terminal Disinfection of Rooms.—At the termination of contagious disease the floor, woodwork, windows, bedstead, chairs, tables, and other furniture of the room occupied by the patient should be disinfected. This is spoken of as terminal disinfection. Scrubbing with soap and hot water usually suffices for this purpose. Floors and walls may be disinfected with a 1:1000 solution of *mercuric chloride* applied with a mop. The solution should be allowed to dry on the floor and walls. A 1 per cent solution of *chlorinated lime* may be used on floors instead of mercuric chloride.

2 methods

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In former years fumigation was a routine procedure in terminal disinfection. By fumigation is meant the destruction of microorganisms by means of gaseous agents. The modern sanitary standards no longer require fumigation in the control of communicable diseases. In some communities, however, it is still used to a limited extent in highly contagious diseases in which the mode of transfer is not definitely known. *Formaldehyde* is the agent generally used. It may be used in the form of *paraformaldehyde*, a pharmacopœial preparation, which occurs as a white friable mass or powder. When heated it yields formaldehyde gas. Another method is to add potassium permanganate crystals to formaldehyde solution. This causes the liberation of formaldehyde gas from the solution.

THERAPEUTIC APPLICATIONS

While the destruction of bacteria on inanimate objects can be effected quite easily, the killing of bacteria on living tissues usually cannot be accomplished as readily. Many antiseptics are protoplasmic poisons as destructive to tissue cells as they are to bacteria; others, while highly effective in checking the growth of bacteria, are without harmful effects on the tissues of the body. Agents used on the body need not necessarily kill bacteria, but are of value if they retard their growth and activities. This affords opportunity for the various defensive mechanisms of the body to become active and attack the bacteria.

Some antiseptics act only on the surface while others have the power to penetrate and thus destroy bacteria in the depths of tissues. Antiseptics that have the property of dissolving dead tissue and pus are of value in the treatment of infected wounds. Agents that are precipitated by body fluids or tissues are usually of little value when employed on living tissues. Antiseptics without irritating effect and without poisonous action are to be preferred.

Skin Disinfection.—Chemical agents are used on the skin to aid the healing of lesions, to treat skin diseases, to disinfect the hands of the nurse and surgeon, and to prepare the skin for surgical operations. It is often desired to reach pathogenic microorganisms not only on the surface, but also in the deeper layers of the skin, the hair follicles and pores of the sweat glands. Agents used on the skin are soap, alcohol, mercurochrome, iodine, acriflavine, boric acid, phenol, and cresol.

The hands of the nurse may be disinfected by scrubbing with *soap* and hot water followed by immersion in a 1:1000 solution of *mercuric chloride*, or a 2½ per cent *phenol* solution. In preparing the skin for an operation the disinfectant should reach not only the bacteria on the surface but also those in the depths of the skin. Due to the selective action of antiseptics surgeons do not depend upon any single agent but use a combination of antiseptics. Agents used for this purpose are *alcohol* (60 to 70 per cent), *iodine* (3 to 5 per cent alcoholic sol.) *picric acid* (6 per cent alcoholic sol.), and *acriflavine* (5 per cent). A 5 per cent solution of neutral acriflavine in 50 per cent alcohol containing 10 per cent of acetone has been found to be effective in disinfecting not only the surface but the entire thickness of the skin.

Mucous Membranes.—A large number of antiseptic agents are used on mucous membranes. In the treatment of infections of the eyes, *boric acid, acriflavine, protargin,* and *silver nitrate* are used. In the nasal cavities, *eucalyptol, menthol, boric acid* and *silver nitrate* are of value. *Dobell's solution* may be used as a nasal spray. In the mouth and throat *boric acid* flavored with *thymol* is frequently employed. *Mercurochrome* in a boric acid solution is of value in the preparatory cleansing of mucous surfaces prior to surgical operations.

Wound Disinfection.—In the treatment of infected wounds the mere application of the antiseptic on gauze is usually not sufficient to check infection. The antiseptic solution must be brought into frequent and intimate contact with the wound. *Dakin's solution* is one of the best disinfectants for contaminated wounds. It is applied by the continuous irrigation method. *Chloramine* may be used in a similar manner and in the presence of much blood it is to be preferred. By the continuous irrigation method, bacteria and their toxic products as well as the poisons resulting from the disintegration of dead tissue are continuously being removed. Thus the infection is checked and the absorption of toxic products prevented.

Small fresh wounds which do not require irrigation may be treated with a 2 per cent solution of *dichloramine* or 1 per cent *mercurochrome* solution. Wounds are sometimes treated with *hydrogen peroxide*, which serves as a cleansing agent and is particularly valuable in suppurating wounds. *Gentian violet* and *neutral acriflavine* are useful wound antiseptics. *Iodoform* or *aristol* may be employed as dusting powders in wounds.

In the treatment of burns a saturated solution (1.2 per cent) of *picric acid* may be used. It tends to prevent infection from developing and also exerts a soothing anodyne action.

Systemic Infections.—Certain systemic infections may be treated by the administration of antiseptics either intravenously or by mouth. Internal antisepsis can be produced only when the invading microorganisms have a special susceptibility to an agent to which the body cells are relatively resistant. Infections caused by staphylococci or streptococci can often be treated successfully by the intravenous injection of *gentian violet*, *acriflavine*, or *mercurochrome*. *Quinine* destroys the organisms of malaria in the blood. *Mercury* and *arsphenamine* are effective against the spirochaetes of syphilis in the living tissues. The *salicylates* are often of value in destroying organisms in the body that give rise to rheumatism.

QUESTIONS FOR CLASS DISCUSSION

1. Define: (a) septic, (b) aseptic, (c) antiseptic, (d) disinfectant, (e) bactericide, (f) germicide, (g) deodorant.
2. Give three specific ways in which chemical agents destroy microorganisms.
3. Why are aqueous solutions more effective than the pure or dry chemical?
4. Do chemical agents destroy bacteria instantly?
5. What is meant by the selective action of antiseptics?
6. Upon what does the germicidal activity of mercuric chloride depend?
7. Give the synonyms for mercuric chloride.
8. Give the advantages and disadvantages of mercuric chloride as a germicide.
9. In what strength is it usually used?
10. Why should distilled water be used in making solutions of mercuric chloride?
11. What is mercurochrome? In which strengths is it used?
12. How does mercurochrome compare with mercuric chloride in penetrating power?
13. Give the properties, actions and uses of silver nitrate.
14. What are colloidal silver preparations? Name two that are official.
15. Name commercial preparations that are similar to the official colloidal silver preparations.
16. Explain the action of chlorine as a disinfectant.
17. What is the chief use of chlorinated lime?

18. Give a synonym for surgical solution of chlorinated soda.

19. How is this solution used? What are its chief advantages?

20. Compare chloramine with dichloramine.

21. What are the chief uses of iodine? Name preparations in which it is used.

22. Give the properties, actions, and uses of iodoform.

23. How does thymol iodide compare with iodoform?

24. Give the properties, actions and uses of phenol.

25. What is meant by phenol coefficient?

26. Give the concentrations in which phenol solutions are generally employed.

27. What is liquefied phenol? Glycerite of phenol?

28. In what form is cresol usually employed? Name commercial preparations similar to the official preparation.

29. What are the chief uses of picric acid?

30. State the source and give the uses of (a) acriflavine, (b) gentian violet.

31. Name and discuss two oxidizing germicides.

32. Describe and give the uses of (a) thymol, (b) menthol, (c) eucalyptol.

33. Of what value is boric acid as an antiseptic?

34. Name a commercial preparation that contains boric acid.

35. In what concentration must alcohol be used to produce germicidal effects?

36. What are soaps? How are they made?

37. What is the germicidal value of soap?

38. What is lime? Give the chief uses of lime.

39. How is milk of lime made?

40. Give the properties, actions and uses of balsams.

41. What is formaldehyde solution? How is it used?

42. Name some physical methods of destroying bacteria.

43. Discuss the disinfection of body discharges.

44. How may utensils and instruments be disinfected?

45. Explain the disinfection of cloth materials.

46. What is meant by terminal disinfection? How is it usually carried out at present?

47. Discuss the disinfection of the skin.

48. Name some disinfectants suitable for use on mucous membranes.

49. Discuss the subject of wound antisepsis.

50. Name antiseptics that are used in the treatment of systemic infections.

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CHAPTER XII

ASTRINGENTS

Mode of Action.
Therapeutic Use.

Principal Astringents.
Vegetable. Mineral.

Astringents (L. *astringere*, to contract) are drugs which harden and contract tissues with which they come in contact. When applied to abraded or mucous surfaces they check the secretions, decrease congestion, and arrest hemorrhage.

MODE OF ACTION

Astringents exert their action by coagulating the albumin in the cells of the superficial layers with which they come in contact. This causes the tissues to contract and become hard. Congestion of blood is decreased by the constriction of the small blood vessels and hemorrhage is arrested by the coagulation of blood albumin at the point of rupture of the blood vessel. Astringents also have an antiseptic action for they coagulate the albumin of the bacterial cells. In strong solution an astringent may exert a caustic effect. Astringents can produce only local effects for they combine with proteins and become insoluble and therefore cannot be absorbed into the circulation.

THERAPEUTIC USE

Astringents are used for the following purposes:

1. To check inflammatory conditions of mucous surfaces. They form a protective coating against irritants of various kinds, decrease congestion and exert an antiseptic action.

2. To harden the skin and treat skin infections. They may be used to prevent the development of bed sores.
3. To check diarrhea. By acting on the cells of the superficial glands they lessen secretory activity.
4. To treat gastric and duodenal ulcers.
5. To check minor hemorrhages.

PRINCIPAL ASTRINGENTS

Astringents may be divided into two classes (1) *vegetable*, and (2) *mineral*. The vegetable astringents owe their action to a group of astringent principles known as *tannins*. The most important tannin is *tannic acid* which in pure form is a light brown powder readily soluble in water. Tannic acid is widely distributed in the vegetable kingdom being found in the roots, bark, and wood of many trees and shrubs. The tannic acid used for medicinal purposes is obtained chiefly from the *nutgalls* of oak trees. *Gallic acid* is another tannin found in various plants. Commercially the tannins are used to transform hides into leather. They precipitate the proteins of the hides, causing the tissues to shrink and become hard and tough.

Therapeutically the tannins are used in the form of pharmaceutical preparations made from tannin containing drugs or in the form of tannic acid. The official *glycerite of tannic acid* is a solution of tannic acid in glycerin. In recent years compounds of tannic acid with albumin and other substances have been introduced. They are particularly valuable as intestinal astringents for they do not decompose in the stomach but dissolve in the alkaline secretions of the intestines, liberate tannic acid and thus exert an astringent action on the intestinal mucosa. Undesirable effects upon the stomach may be avoided by the use of these compounds. Examples of such compounds are given below in the list of synthetic tannic acid compounds.

Crude Drugs Containing Tannins

Nutgalls, *U.S.P.*, galls from young twigs of oak trees. They contain about 30 to 60 per cent tannic acid and 2 to 3 per cent gallic acid.

Krameria, *U.S.P.*, roots of Peruvian Rhatany, a low shrub growing in Peru and Brazil. It contains kramero-tannic acid.

Gambir, *U.S.P.*, leaves and twigs of Ourouparia Gambir, a climbing plant growing in the Malay Archipelago.

Kino, *U.S.P.*, juice from trunk of Pterocarpus Marsupium, a tree which grows in the East Indies. It contains kino-tannic acid.

Hamamelis, *N.F.*, leaves of witch-hazel, which grows in North America and contains about 8 per cent tannic acid.

Uva Ursi, *U.S.P.*, leaves of Bearberry, a small evergreen shrub which grows in North America and Europe.

Haematoxylin, *N.F.*, heartwood of Logwood tree which grows in Central America and the West Indies.

Synthetic Tannic Acid Compounds

Albumin Tannate, *U.S.P.*, a compound of albumin and tannic acid.

Tannyl Acetate, *U.S.P.*, obtained by the acetylization of tannic acid.

Protan, *N.N.R.*, a chemical combination of tannic acid with casein.

Tannalbin, an albuminous compound of tannic acid.

Tannoform, a compound of tannic acid and formaldehyde.

The inorganic astringents are various salts of metals, the most important of which are listed below:

Alum
Lead Acetate
Silver Nitrate
Bismuth Subnitrate
Bismuth Subcarbonate
Zinc Oxide
Zinc Sulphate
Zinc Chloride
Potassium Chlorate
Ferric Chloride

Alum may be sulphate of aluminum and potassium $[AlK(SO_4)_2 + 12H_2O]$, or the sulphate of aluminum and ammonia, [$AlNH_4(SO_4)_2 + 12H_2O$]. Alum is readily soluble in water or glycerin. *Burnt alum,* which is alum with the water of crystallization driven off, has a strong affinity for water and is strongly astringent. Burnt alum in alcoholic solution is used to harden the skin to prevent the development of bed sores. Alum is used externally in $\frac{1}{4}$ to 3 per cent solutions. The dose for internal use is 0.5 gram.

Lead acetate [$Pb(C_2H_3O_2)_2 + 3H_2O$] commonly called sugar of lead is used externally in $\frac{1}{4}$ to 1 per cent solutions. The dose for internal use is one grain. When given over a prolonged period of time it may cause chronic poisoning.

Silver nitrate [$AgNO_3$], may be used in a solid molded form in which it is fused with a small amount of potassium nitrate or silver chloride to harden it. In this form it is known as *lunar caustic* and is used in the treatment of warts, ulcers, and chancres. It is not only astringent but also caustic in its action. Silver nitrate is also used in solutions of various concentrations.

Bismuth subnitrate [$BiONO_3 + H_2O$] and subcarbonate [$(Bi_2O_2CO_3)_2 + H_2O$] are used in the treatment of gastric ulcer, diarrhea, and skin diseases. They are almost insoluble in water and are used for their protective, mild astringent, and antiseptic properties. For internal use they are usually prescribed in powders or capsules. They are not absorbed from the stomach or intestine but absorption occurs when used in wounds and symptoms of poisoning may result.

Zinc salts are important astringents. *Zinc sulphate* [$ZnSO_4 + 7H_2O$] is used in the treatment of conjunctivitis ($\frac{1}{4}$ per cent sol.) and gonorrhea ($\frac{1}{4}$ to 1 per cent sol.). *Zinc oxide* [ZnO] is insoluble in water and is used as a dusting powder, combined with starch or talc, or in the form of an ointment. *Zinc chloride* [$ZnCl_2$] is used in 1 to 2 per cent solutions as an astringent mouth wash.

Potassium chlorate [$KClO_3$] is used in the treatment of inflammatory conditions of the mouth and throat in the form of a wash or gargle. When swallowed it causes symptoms of poisoning. It irritates the gastro-intestinal tract and kidneys and transforms the hemoglobin of the red blood corpuscles into methemoglobin.

Ferric chloride [$Fe_2Cl_6 + 12H_2O$] is used as an astringent or styptic in the nose, mouth and throat. It is frequently used to check bleeding after removal of tonsils or extraction of teeth.

Questions for Class Discussion

1. What are astringents?
2. Explain the mode of action of astringents.
3. Give the therapeutic uses of astringents.
4. Name some tannin-bearing drugs.
5. What is the source of medicinal tannic acid?
6. Of what value are the synthetic tannic acid compounds?
7. What is alum? Burnt alum?
8. Which salt of lead is used as an astringent?
9. What is lunar caustic?
10. Name two bismuth salts used as astringents. Are they soluble or insoluble?
11. Which zinc salts are used as astringents? Are they soluble or insoluble?
12. Explain the use of potassium chlorate.
13. What are the symptoms of potassium chlorate poisoning?
14. Give the chief purposes for which ferric chloride is used.

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CHAPTER XIII

ACTION OF DRUGS ON THE BODY

Local Action.
Systemic Action.
How Drugs Produce their Effects.
  Action due to Ionization.
  Action due to Osmotic Pressure.
  Actions of Vaccines & Antisera.
Selective Action.
Absorption and Excretion.
Tolerance and Habituation.
Cumulative Action.
Synergism and Antagonism

LOCAL ACTION

Local action may be produced wherever drugs can be applied, namely, the skin and mucous membranes. Drugs are used for local action on the skin chiefly to produce the following effects:

1. To relieve pain (anodyne).
2. To produce local anaesthesia.
3. To contract and harden the skin (astringent).
4. To treat skin infections.
5. To soothe (emollient).
6. To destroy abnormal growths (caustic).
7. To check bleeding (styptic).
8. To treat wounds.

The medicament may be in the form of an ointment, paste, cerate, liniment, plaster, antiseptic or astringent solution.

Drugs are used on mucous membranes for various purposes but chiefly for the treatment of infections in the nose, mouth, throat, stomach, rectum, urethra, etc. They are also used to produce a soothing effect (demulcent) in case of irritation by poisons. Various solutions such as gargles, sprays, and douches are used. Suppositories may be used to treat the rectum, urethra, and vagina. Inhalations may be given to treat the mucous membranes of the respiratory tract.

SYSTEMIC ACTION

To treat organs not directly accessible, such as the heart, the liver or kidneys, the drug must be introduced into the circulation to reach the part where it is to exert its action. Through chemical or physical action on body cells drugs may *increase* or *lessen* their activities. A drug that increases the activity of cells is called a *stimulant*, while one that decreases activity is known as a *depressant.* Excessive stimulation results in *irritation.* Prolonged stimulation may pass into depression and later exhaustion. Prolonged depression may lead to paralysis or death.

The action which a drug exerts on the normal animal body is spoken of as the *physiological action* of the drug, while its action in combating disease is termed *therapeutic action.* In some cases the physiological action is similar to the therapeutic action but in other cases it is not.

HOW DRUGS PRODUCE THEIR EFFECTS

The processes of life that occur in the tissues of the body are essentially *chemical* and *physical* changes that take place within the cells. The cell, which is the unit of structure of the body, is a complex colloidal solution in which chemical changes, such as *synthesis, reduction* and *oxidation* are constantly taking place. The physical changes that take place are due largely to differences in *osmotic pressure* between the cells and the fluids that surround them.

The physical and chemical structure of the cell renders it susceptible to certain substances that may be present in the lymph that surrounds it. Disease may alter the chemical composition of certain cells and thus affect their functional activities. Drugs change the chemical or physical environment of the cells and thus either lower or increase their activities. They assist the body in restoring life's normal chemical and physical reactions.

Medicinal substances produce their effects in a number of different ways. Some form a *chemical union* with certain ingredients of the cells and thus produce their effects by chemical action. In some cases the chemical action is brought about by the drug in its original form while in other cases action does not occur until the drug is split up in the body into its constituent parts. A drug which ionizes produces chemical changes in the cells through its *ions* while a non-electrolyte produces its effects through its *molecules.* Some drugs act by virtue of their physical relations to the cells of the body. This occurs with drugs that change the osmotic pressure of the blood or other body fluids. A few drugs seem to act by dissolving out some of the constituents of certain cells of the body.

Action Due to Ionization.—The effects of many drugs depend upon their dissociation into ions. A certain ion in a solution may be more powerful in its action than the other ions. In strychnine sulphate the *strychnine ion* dominates the action while the sulphate ion is rather feeble. In potassium chlorate the *potassium ion* predominates while in potassium bromide the *bromine ion* is most active. In sodium bicarbonate [$NaHCO_3$] dissociation into Na and HCO_3 occurs. The HCO_3 combines with water and forms CO_2 and OH-ions.

The action of this drug is due to the OH-ions. The action of salts of the heavy metals is dependent upon the *metallic ions.*

Action Due to Osmotic Pressure.—Certain substances when administered as medicines effect the cells of the body by means of a force known as osmotic pressure. Osmotic pressure is exhibited by many substances in solution but among medicinal preparations occurs chiefly in the neutral salts and it is therefore spoken of as "*salt action.*" The salt action of a substance differs entirely from its chemical action and depends upon the osmotic pressure, namely, the number of molecules or ions in solution without regard to their chemical nature. It is thus a physical effect.

Each cell of the body is surrounded by a surface film or membrane which exhibits a differential permeability, permitting certain substances to enter the cell while excluding others. There is a delicate balance between the colloids of the cell protoplasm and the osmotic pressure of the crystalloids within the cells and in the blood and lymph streams. Solutions not isotonic with the blood when introduced into the body disturb the osmotic-pressure balance of the body. If the solution is hypertonic water is withdrawn from the tissues and the concentration of their soluble constituents is increased. If it is hypotonic the cells take up water and the concentration of their constituents is reduced. Both hypotonic and hypertonic solutions have an irritating action on wound surfaces.

When the intestine is at rest it has an osmotic pressure identical with that of the blood. When a concentrated solution of a salt, such as magnesium sulphate (Epsom salt), which is not readily absorbed from the intestine, is taken by mouth it dissociates into Mg+ and SO_4- ions. Neither of these ions are absorbed to an appreciable degree but remain in the intestinal tract where they serve to increase the osmotic pressure. They make of the intestinal contents a hypertonic solution which withdraws water from the surrounding tissues into the intestinal tract until the intestinal contents become isotonic with the body fluids. The retained fluid in the intestine acts as a mechanical stimulus to the intestinal muscles and thus promotes peristalsis.

Certain salts exert both salt action and chemical action in the body. If a salt contains an ion which is very potent, salt action will not occur when it is administered to a patient because it cannot be given in large enough quantity to affect the osmotic equilibrium of the blood, without doing harm to the patient.

Actions of Vaccines and Antisera.—**Vaccines** are preparations which contain pathogenic microorganisms that have been either killed or attenuated and suspended in glycerin or physiological salt solution. They are usually used to prevent disease and are injected into the body by means of a hypodermic needle. Smallpox vaccine, however, is administered in a somewhat different manner. In the body the microorganisms disintigrate releasing certain chemical constituents which stimulate the body tissues to produce chemical substances known as *antibodies*. Antibodies have the power to combat microorganisms in the body. They are specific in their action in that they can act only against those organisms that stimulated their production.

Antisera are preparations which contain antibodies. They are obtained from the blood serum of animals that have been inoculated either with pathogenic bacteria or their toxins. They are usually used in the treatment of disease rather than prevention and are injected into the body. They provide the body with the necessary antibodies to overcome infection. Diphtheria antitoxin, for example, is an antiserum which combines with the toxin produced in the body in diphtheria and thus prevents the toxin from doing injury to the tissues.

SELECTIVE ACTION

The stimulating or depressing effects of a drug can be made use of in therapeutics due to the fact that the drug does not produce its action on all of the tissues of the body but possesses a selective affinity for certain groups of cells. The drug is distributed to all cells but only those that are susceptible are influenced by it. For this reason it is possible to administer digitalis to stimulate a failing heart, morphine to depress the nervous system so that severe pain may be subdued, and strychnine to stimulate the spinal cord and medulla oblongata. Selective affinity may be explained by assuming that certain cells contain peculiar chemical substances for which the drug has a selective affinity. It is due to the selective action of drugs that a desired tissue or organ may be reached with great precision and without effect on other tissues.

ABSORPTION AND EXCRETION

The process by which a drug enters the blood from a mucous surface or the skin is known as *absorption*. The intensity of the action of a drug is determined by the rate of absorption. Some drugs are absorbed in a few seconds while others are absorbed very slowly. The speed of absorption depends upon the nature of the drug, the rapidity of the circulation of the blood, and the mode of administration.

The body tends to free itself of foreign substances. This is known as *excretion*. Drugs are eliminated either unchanged or after chemical combination with some products of the body, after *oxidation* to other compounds, or *reduction* to simpler compounds. Ether is excreted unchanged. Antipyrin and chloral are eliminated as compounds of glycuronic acid. Alcohol is in most part oxidized to carbon dioxide and water and excreted as such. Excretion may take place through the kidneys, intestines, liver, salivary glands, or the skin. Ether is eliminated through the lungs, strychnine is excreted by the kidneys, and morphine by the stomach and intestine.

TOLERANCE AND HABITUATION

Since drugs are destroyed or eliminated rather rapidly by the body it is necessary to administer them periodically in order to maintain their effect. With some drugs the dose must be increased progressively for the body developes its power of destruction or elimination. This condition is known as *tolerance*. In some cases tolerance is due to the fact that the rate of absorption diminishes. This is true of arsenic.

In some cases the body becomes *habituated* to the action of certain drugs and does not function well without them. Examples of drugs that are habit forming are morphine, cocaine, and their derivatives. Such drugs are called *narcotics*.

CUMULATIVE ACTION

The action of some drugs increases when the dose is continued for some time. This is due to the fact that the cells of the body store these drugs and each dose adds to the amount present until poisonous quantities exist in the body. Digitalis is an example of a drug in which cumulative action occurs. Toxic symptoms may arise if this drug is continued for a time. Cumulative action also occurs with mercury, arsenic, and the iodides.

SYNERGISM AND ANTAGONISM

When two or more drugs having a similar action are given at the same time the effect is often more pronounced than that produced by one of the drugs alone in a dose equal to the combined dose. This cooperative action of drugs is known as *synergism*. Several cathartics administered simultaneously often produce greater action than any one alone is capable of producing in a dose equal to the combined dose. A mixture of bromides and chloral is more effective in producing sleep than chloral alone in a larger dose.

The opposite condition, in which a drug counteracts the action of another, is spoken of as *antagonism*. When an overdose of a potent drug has been taken it is often possible to counteract its toxic effect by means of a drug which is antagonistic to it. An overdose of bromides, for example, may be counteracted with strychnine, or an overdose of digitalis with aconite or morphine.

Questions for Class Discussion

1. What is meant by the local action of drugs?
2. Give the chief local effects of drugs on the skin.
3. In what forms are medicaments used on the skin?
4. For what purposes are drugs used on mucous membranes?
5. What is meant by the systemic action of drugs?
6. Define: (a) stimulant, (b) depressant, (c) physiological action, (d) therapeutic action.
7. How do drugs produce their effects?
8. Distinguish between the chemical and physical actions of drugs.
9. Explain the action due to ionization.
10. Discuss the action of drugs due to osmotic pressure.
11. Explain the actions of vaccines and antisera.
12. What is meant by selective action?
13. Of what therapeutic importance is the selective action of drugs?
14. How do drugs compare in rate of absorption?
15. Discuss the excretion of drugs from the body.
16. Explain tolerance and habituation as related to drugs.
17. What is meant by cumulative action? Give examples.
18. Explain synergism and antagonism.

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CHAPTER XIV

THERAPEUTIC CLASSIFICATION OF DRUGS

- Skin and Mucous Membranes.
  - Demulcents. Emollients. Antiseptics.
  - Disinfectants. Astringents. Styptics.
  - Counterirritants. Caustics.
- Digestive System.
  - Stomachics. Bitters.
  - Digestants. Carminatives.
  - Antacids. Emetics. Antiemetics.
  - Cathartics. Anthelmintics.
- Nervous System.
  - Stimulants. Sedatives. Analgesics.
  - Anodynes. Hypnotics. Anesthetics.
  - Antispasmodics.
- Blood and Circulatory System.
  - Cardiac Stimulants. Vasodilators.
  - Cardiac Depressants. Hematinics.
  - Vasoconstrictors. Hemostatics.
- Respiratory System.
  - Expectorants. Stimulants. Depressants.
- Genito-urinary Tract.
  - Diuretics. Emmenagogues. Ecbolics.
- Specifics and Prophylactics.
- Miscellaneous Groups.
  - Antipyretics. Mydriatics.
  - Diaphoretics. Miotics.

The medicaments that make up the present day Materia Medica may be classified, as above, on the basis of their action in disease. Some drugs exert more than one type of action and consequently are classifiable under more than one heading. Drugs that act as astringents, for example, also exert antiseptic and styptic actions. This chapter introduces the student to the terms used in describing the therapeutic actions of drugs. Each term should be carefully studied and become a part of the student's vocabulary.

SKIN AND MUCOUS MEMBRANES

Demulcents are agents which exert a soothing effect upon inflamed mucous surfaces. They are usually of an adhesive nature, chemically inert, and act mechanically. They may be taken by mouth to allay irritation of the stomach and esophagus following the ingestion of irritant poisons. Examples of demulcents are mucilage of acacia, flaxseed, starch, milk, and white of egg.

Emollients are soothing substances applied to the skin. They are usually of a fatty or oily nature and serve to soften, soothe, protect, and relax the skin. They may be employed for chapped skin, burns, abrasions, and inflammatory affections of the skin. Examples of emollients are ointment of rose water (cold cream), petrolatum, ointment of zinc, cocoa-butter, and fixed oils.

Antispetics are agents that tend to retard the growth of microorganisms. **Disinfectants** are substances that destroy disease producing microorganisms. These two terms are often used indiscriminately since it is not always possible to tell whether an agent merely retards growth or actually destroys microorganisms. Examples are boric acid, mercurochrome, tincture of iodine, Dakin's solution, silver nitrate, and potassium permanganate.

Astringents are drugs which contract and harden tissue. They are applied to mucous membranes and the skin and produce their action by precipitating albumins and other proteins in the superficial layers, thus causing a hardening and contraction of the surface cells. Astringents are used to check inflammatory conditions of mucous surfaces, to treat ulcers, check diarrhea and hemorrhages. Examples are alum, silver nitrate, ferric chloride, lead acetate, zinc oxide, and tannic acid.

Styptics are agents that arrest capillary hemorrhage in the skin or mucous membranes. Astringents are usually used for this purpose. By precipitating the protein of the blood they close the rupture in the blood vessels.

Counterirritants are irritating substances, applied to the skin, that counter or check pain and inflammation in the internal tissues or organs. They cause a dilation of the blood vessels of the skin (hyperemia) and thus relieve congestion of blood in the inflamed internal organs. They also relieve pain through their effect on the nervous system. Counterirritants are used in pleurisy, pneumonia, cardiac pain, neuralgic and joint pains. A counterirritant that is used to merely produce an acute hyperemia of the skin is called a *rubefacient*, while one that is used to produce blistering is spoken of as a *vesicant*. Examples of rubefacients are camphor, menthol, oil of turpentine, capsicum, and mustard. Ammonia water and cantharides cerate are used as vesicants.

Caustics (escharotics) are irritant substances that cause death of tissue. They are used to remove abnormal growths on the skin and mucous membranes, such as warts, polypi, and hypertrophied soft tissues. Examples of caustics are sulphuric acid, glacial acetic acid, sodium hydroxide (caustic soda), silver nitrate (lunar caustic), and potassium hydroxide (caustic potash).

DIGESTIVE SYSTEM

Stomachics are agents which improve the appetite and stimulate digestion. Some of the remedies employed for this purpose have a bitter taste by virtue of which they stimulate the taste-buds and thus improve the appetite and the flow of digestive juices. Such drugs are called *bitters*. Examples of bitters are gentian, dandelion (taraxacum), nux vomica, bitter orange-peel, and cinchona.

Digestants are drugs which are capable of taking part in the process of digestion. The most valuable digestant is hydrochloric acid, the natural acid of the stomach. Other digestants are pepsin and pancreatin obtained from animal glands, and two vegetable enzymes, namely, papain which digests proteins, and diastase which digests starch.

Carminatives are agents that aid in the expulsion of gas from the stomach or intestine. The aromatic volatile oils are used for this purpose. They are slightly antiseptic and, therefore, check the growth of the microorganisms causing the gas, and stimulate the stomach and intestine sufficiently to bring about the expulsion of the gas.

Antacids are mild alkaline drugs used to reduce the hydrogen ion concentration of the contents of the stomach in cases of hyperacidity. The stomach contains hydrochloric acid which may be present in excessive amounts so that the hydrogen ion concentration rises above normal. The acidity may be reduced with hydroxyl ions. The milder salts which give an alkaline reaction, such as the hydroxides of calcium (lime water) and magnesium (milk of magnesia), and the bicarbonates of potassium and sodium may be used for this purpose. Bismuth subnitrate is also used.

Emetics are agents employed to induce vomiting. Some act locally by irritating the pharynx or stomach (local emetics), while others act by stimulating the vomiting center in the medulla (central emetics). The most important local emetics are mustard, ipecac, zinc sulphate, and copper sulphate. The only centrally acting emetic in therapeutic use is apomorphine which is a synthetic alkaloid derived from opium and is administered hypodermically.

Antiemetics are remedies which check nausea and vomiting. If the vomiting is due to local irritation insoluble bismuth salts, milk of magnesia, or sodium bicarbonate may be used. If it is due to sensitiveness of the vomiting center a sedative such as morphine, chloral hydrate, or salts of bromine may be used.

Cathartics are drugs that produce evacuation of the bowels. They produce their action by irritating the intestines or by increasing the bulk of the feces. Cathartics may be classified according to the degree of their action, as follows:

(1) *Laxatives* produce a moderate peristalsis.

Mineral Oil.
Cascara Sagrada.
Agar Agar.
Phenolphthalein.
Olive Oil.
Glycerin.

(2) *Purgatives* produces a more active peristalsis.

Senna.
Aloes.
Castor Oil.
Rhubarb.
Podophyllin.
Calomel.

(3) *Hydragogues* (saline purgatives) produce frequent watery stools.

Magnesium Sulphate (Epsom Salt).
Sodium Sulphate (Glauber's Salt).
Sodium Phosphate.
Magnesium Citrate.

(4) *Cholagogues* stimulate the flow of bile causing green-colored and liquid stools. Bile salts, calomel, aloes, and podophyllin have a cholagogue action.

Anthelmintics (vermicides, vermifuges) are drugs which exert a toxic effect on intestinal worms and cause their expulsion. Oleoresin of aspidium is used to expell tape-worms, santonin for round-worms, quassia for thread-worms and thymol for hook-worms.

NERVOUS SYSTEM

Stimulants of the nervous system are drugs that increase the activity of the brain and spinal cord. Those that increase the activity of the brain are called *cerebral stimulants.* Examples of such drugs are caffeine and atropine. Strychnine is an example of a drug that stimulates the spinal cord. Nervous stimulants are used to counteract the depressing effects of large doses of narcotic drugs and in conditions of collapse.

Sedatives are drugs which allay excitement and exert a soothing effect on the nervous system. They act by diminishing the conduction of impressions to the brain. Excessive use of sedatives may cause the cardiac and respiratory actions to cease. Morphine opium, sodium bromide, and valerian are examples of sedatives.

Analgesics are drugs which relieve pain when introduced into the circulation. They act upon the sensory nerve areas of the brain. Examples are morphine, acetanilid, phenacetin, aspirin, atophan, and cannabis indica.

Anodynes diminish pain in the skin or mucous membranes when applied locally. The term analgesic is at present often used to include anodynes. Examples of anodynes are menthol, camphor, aconite, and local anesthetics.

Hypnotics (somnifacients, soporifics) are drugs which induce sleep. They depress the cerebral cells and thus diminish mental activity. They are useful in cases of insomnia, nervous excitement, and certain spasmodic affections. Chloral hydrate, veronal, bromural, chloretone, and sulfonal are examples of hypnotics.

Anesthetics are agents which temporarily abolish sensory nerve function and bring about insensibility. They are either local or general in their action. Local anesthetics paralyze the sensory nerves in the tissues to which they are applied. When injected into the lumbar region of the spinal cord a sensory paralysis of the legs and trunk results. Epinephrine is often injected with local anesthetics because it constricts the blood vessels and prevents the rapid absorption of the anesthetic, thus reducing the amount needed and prolonging the action. Examples of local anesthetics are cocaine, procaine, ethyl chloride, and orthoform. General anesthetics produce unconsciousness and insensibility. Examples are ether, chloroform, nitrous oxide, ethylene, and ethyl chloride.

Antispasmodics are drugs which relieve spasms of voluntary or involuntary muscles. They are used in asthma, respiratory diseases, hysteria, and epilepsy. Among the drugs used are bromides, morphine, stramonium, camphor, hyoscyamus, ephedrin, and aconite.

BLOOD AND CIRCULATORY SYSTEM

The heart muscle maintains its rhythmic contractions automatically; but its rate is controlled by the vagus nerve, which has a restraining action and the accelerator nerves which have a stimulating action. These nerves may be affected by drugs.

Cardiac stimulants are remedies which improve the action of the heart. Some act directly on the heart muscle, while others act by paralyzing the inhibitory vagus nerve. Some act on both the heart muscle and the vagus nerve. Digitalis stimulates the heart muscle and makes the heart strokes more powerful, but it also stimulates the vagus nerve which causes the heart to beat more slowly. Although the heart is slowed down the circulation is improved through the stimulating effect on the heart muscle. Atropine acts as a cardiac stimulant by paralyzing the vagus nerve and thus quickening the heart beat. Other cardiac stimulants are strophantus, squill, camphor, ammonia, and caffeine.

Cardiac depressants are drugs which slow the action of the heart. This is accomplished by depressing the cardiac muscle or stimulating the vagus nerve. Slowing the action of the heart is useful when it is inflamed or over-excited. Aconite and veratrum have this action.

Vasoconstrictors are agents which bring about constriction of the blood vessels, chiefly the arteries. This may be accomplished by a direct stimulation of the muscle fibers in the walls of the vessels or by stimulating the vasoconstrictor center in the medulla oblongata. They are used to check hemorrhage.

Epinephrine, ephedrine, antipyrin, camphor, and ergot have this action.

Vasodilators are remedies which dilate the arteries. This is accomplished by depression of the muscle fibers in the vessels or by stimulation of the vasodilator center in the medulla. Vasodilation is useful in lowering high blood pressure in relieving internal congestion by equalizing the blood pressure. Amyl nitrite, given by inhalation, paralyzes the smooth muscles of the blood vessels and thus produces vasodilation. Other nitrites such as nitroglycerin, spirit of nitrous ether, and ethyl nitrite produce a similar action.

Hematinics are drugs which tend to increase the hemoglobin of the blood. Hemoglobin is a complex compound of a protein (globin) with hematin ($C_{34}H_{35}N_4FeO_5$) which contains an oxide of iron. It occurs in red blood corpuscles and is necessary for the conveyance of oxygen from the lungs to the various tissues of the body. The body maintains a reserve supply of iron in the liver, spleen, and bone marrow. In anemia this reserve supply becomes exhausted. This condition can often be corrected by the administration of iron preparations.

Hemostatics are agents that arrest internal hemorrhage. Agents that favor coagulation of blood, such as blood-serum, whole-blood, and tissue extracts are useful for this purpose.

RESPIRATORY SYSTEM

Expectorants are agents which modify expectoration by increasing its amount or rendering it more fluid and promoting its expulsion. They are used in cough and bronchitis to remove the increased secretion of mucus which may obstruct breathing. Drugs used for this purpose are ipecac, ammonium carbonate, potassium iodide, creosote, and balsam.

Respiratory stimulants are drugs which stimulate the respiratory center in the medulla and thus accelerate breathing. They are useful in certain conditions such as poisoning, pneumonia, and collapse, in which the breathing center becomes depressed. Drugs used for this purpose are ammonia, caffeine, strychnine, camphor, and atropine.

Respiratory depressants depress the respiratory center and produce slow and shallow breathing. Examples are morphine, aconite, chloral, quinine, and the bromides.

GENITO-URINARY TRACT

Diuretics increase the flow of urine. They act by, (1) increasing the circulation of blood through the kidneys, (2) stimulating the secreting cells in the kidneys, or (3) increasing the water content of the blood (salt action). Digitalis acts as a diuretic by improving the circulation. Other diuretics are potassium nitrate and salts of organic acids (acetates and citrates).

Emmenagogues are drugs which tend to bring on or increase the menstrual flow. They act either directly by stimulating the uterus or indirectly by exerting a tonic action upon the blood and nerves. Direct stimulants are ergot, apiol, and hydrastis while iron, strychnine, and cod-liver oil act by improving the general health.

Ecbolics (oxytocics) are agents which cause the uterus to contract. Pituitary extract may be used to hasten labor while ergot is used to stop hemorrhage of the uterus after childbirth. Ergot contracts the relaxed uterus and closes the bleeding sinuses.

SPECIFICS AND PROPHYLACTICS

Specifics are drugs that exert a curative action in that they destroy the causative agents of disease in the tissues of the body. Quinine destroys the organisms of malaria in the blood. Mercury and arsphenamine are specifics in syphilis. Diphtheria antitoxin cures diphtheria.

Prophylactics are agents which tend to prevent the development of disease. Smallpox and typhoid vaccines, and diphtheria toxin-antitoxin are examples.

MISCELLANEOUS GROUPS

Antipyretics (febrifuges) are agents that lower the body temperature in fever. They act either by diminishing the production of heat in the body or by increasing the loss of heat. Reduction of temperature may be brought about by means of ice-bags, cold compresses, rectal irrigation with ice-water, or by means of drugs. Drugs employed are acetanilid, quinine, salicylic acid, aspirin, atophan, and phenacetin.

Diaphoretics (sudorifics) are remedies which promote sweating. Diaphoresis is resorted to to relieve or assist the kidneys in the removal of waste matter from the blood. It is also used to remove fluid from the body in dropsy and to accelerate the elimination of certain poisons from the body. Pilocarpine acts as a diaphoretic by directly stimulating the nerves of the sweat glands.

Mydriatics are drugs which dilate the pupils of the eyes and cause a temporary loss of accomodation so that the eyes remain focused for distant objects only. They are used by ophthalmologists for making eye examinations and also to break down adhesions of the iris. Drugs used for this purpose are atropine, hyoscyamine, cocaine, and ephedrine.

Miotics are drugs which constrict the pupils of the eyes and cause a temporary loss of accommodation so that the eyes remain focused for near objects only. Eserine, pilocarpine, and arecoline are used for this purpose.

Questions for Class Discussion

Note: The student should be able to define each term in the chapter and in addition answer the following questions:

1. How do demulcents differ from emollients?
2. Name agents used as demulcents and emollients.
3. Compare astringents with styptics.
4. What is the difference between a styptic and a hemostatic?
5. How do counterirritants produce their effects?
6. Give examples of drugs used as (a) rubefacients, (b) vesicants, (c) caustics, (d) bitters, (e) digestants.
7. How do the following produce their effects; (a) carminatives, (b) antacids, (c) emetics, (d) antiemetics?
8. Name drugs used as (a) carminatives, (b) antacids, (c) emetics, (d) antiemetics, (e) laxatives, (f) purgatives, (g) hydragogues, (h) cholagogues, (i) anthelmintics.
9. Give examples of drugs that stimulate (a) the brain, (b) the spinal cord.
10. Compare analgesics with anodynes.
11. Name drugs used as, (a) sedatives, (b) analgesics, (c) anodynes, (d) hypnotics, (e) local anesthetics, (f) general anesthetics, (g) antispasmodics.
12. Explain the action of, (a) cardiac stimulants, (b) cardiac depressants, (c) vasoconstrictors, (d) vasodilators. Give examples.

13. Name drugs used as (a) hematinics, (b) hemostatics, (c) expectorants, (d) respiratory stimulants, (e) respiratory depressants.

14. How do diuretics produce their effects?

15. Give examples of drugs used as (a) emmenagogues, (b) ecbolics, (c) specifics, (d) prophylactics, (e) antipyretics, (f) diaphoretics, (g) mydriatics, (h) miotics.

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CHAPTER XV

DOSES AND THEIR PREPARATION

Definitions.
Factors Which Determine the Dose.
Average Doses.
Frequency of the Dose.
Domestic Measure of Dosage.
Doses for Children.
Needle Dosage.
Calculation of Needle Doses.
Problems.
Solutions for Needle Administration.

DEFINITIONS

The *dose* of a drug refers to the amount ordinarily required to produce a therapeutic effect. The term *dosage* refers to the determination and regulation of doses. The study of dosage is known as *posology.* The smallest amount of a drug capable of producing a therapeutic effect is called the *minimum dose.* The largest amount of a drug that can be administered without producing deleterious effects is called the *maximum dose.* A quantity larger than the maximum dose is an overdose or *toxic dose.* A *lethal dose* is a dose which causes death.

FACTORS WHICH DETERMINE THE DOSE

When a physician determines the dose to be administered he takes the following factors into consideration:

1. The Age of the Patient.—The adult dose of a drug is for persons between twenty and sixty years of age. A person below twenty or above sixty years of age should receive less than the adult dose.

2. The Weight of the Patient.—The adult dose is based upon the average weight of 150 pounds. The dose for a large person should be larger than that for a small person. In the body of a large person the drug is diluted more than in a small person and consequently more is needed to produce the desired effect. Adipose tissue, however, should not be included in estimating weight, since it is not acted upon by drugs.

3. The Sex of the Patient.—Women usually require smaller doses than men chiefly because they are lighter in weight but also because they are more sensitive to the action of drugs. The dose for a woman is, approximately, four-fifths of that for a man. In pregnancy or lactation certain drugs must be administered only in small doses or not at all to prevent abortion, or harmful effects of the drug on the suckling infant. Certain drugs, such as opium, arsenic, bromids, mercury, quinine, cathartics, and iodids are excreted in the milk.

4. The Mode of Administration.—When given by needle the dose is smaller than when given by mouth or rectum. The needle dose is usually one-fourth to one-half, while the rectal dose is twice the dose by mouth.

5. Tolerance and Habituation.—If the drug gives rise to a condition of tolerance when administered over a period of time, the dose must be gradually increased to maintain the effect of the drug. When a person has become habituated to a drug a dose larger than the average is required.

6. Idiosyncrasy.—When a person has an idiosyncrasy toward a drug, that is, if he is either unusually susceptible or more or less indifferent to it, it must be administered either in smaller or larger doses than usual. Drugs which often give rise to unusual reactions in patients are atropine, morphine, quinine, iodine, and the salicylates.

AVERAGE DOSES

Since the dose of a drug cannot become a fixed quantity the United States Pharmacopœia and National Formulary give "average doses" to serve as a guide to physicians and pharmacists. If the average

TABLE OF USUAL DOSES

Official preparations	Metric	Apothecaries'
Fluidextracts:		
Potent	0.065 cc.	♏.i
Non-potent	1.0 to 2.0 cc.	♏.xv to xxx
Tinctures:		
Potent	0.6 cc.	♏.x
Non-potent	4.0 cc.	ʒi
Extracts:		
Potent	0.015 Gm.	gr.¼
Non-potent	0.3 Gm.	gr.v
Powders:		
Potent	0.3 Gm.	gr.v
Non-potent	2.0 Gm.	gr.xxx
Syrups:		
Potent	1.0 to 2.0 cc.	♏.xv to xxx
Non-potent	8.0 cc.	ʒii
Solutions:		
Potent	0.2 cc.	♏.iii
Non-potent	16.0 cc.	ʒiv
Waters:		
Potent	1.0 cc.	♏.xv
Non-potent	16.0 cc.	ʒiv
Spirits	1.0 to 2.0 cc.	♏.xv to xxx
Elixirs	4.0 cc.	ʒi

dose of a drug is known one can readily calculate the dose of the fluidextract, tincture or extract of that drug. Since all fluidextracts are 100 per cent in strength, the dose is that of the drug. Potent tinctures have a strength of 10 per cent and, therefore, the dose is ten times that of the fluidextract. Extracts are, approximately, four times as strong as the crude drug and hence the dose is one-fourth as much as that of the drug. If the dose of a drug is one grain, the dose of the fluidextract is one minim, the tincture ten minims, and the extract one-fourth grain.

FREQUENCY OF THE DOSE

Since drugs are destroyed or eliminated more or less rapidly by the body it is necessary to administer them at regular intervals to maintain their effects. Examples of drugs which are eliminated rapidly are ammonia, caffeine, camphor, chloral, iodids, and strychnine. These drugs may be administered every hour to every three hours. Examples of drugs which are eliminated slowly are arsenic, atropine, bromids, digitalis, mercury, quinine, and thyroid. These drugs should not be administered oftener than once or twice a day.

DOMESTIC MEASURE OF DOSAGE

Since patients usually are not familiar with the fluid measures used in measuring drugs and do not have measuring glasses on hand, it is customary to direct them to measure doses with the household measures with which they are familiar. The table that follows is only approximately correct, since domestic measures have not been standardized and vary considerably in capacity.

Table of Domestic Measures

1 teaspoonful = f.ʒi or 4.0 cc.
1 dessertspoonful = f.ʒii or 8.0 cc.
1 tablespoonful = f.ʒiv or 16.0 cc.
1 tumblerful = f.℥viii or 240.0 cc.

DOSES FOR CHILDREN

The dose of a drug for a child may be calculated from the adult dose. The rule most commonly used is the one given below:

Young's Rule:

$$\frac{\text{age}}{\text{age} + 12} \times \text{adult dose} = \text{child dose.}$$

If the adult dose of a drug is ♏.xxx, the dose for a six year old child is $\frac{6}{6 + 12} \times 30 = 10$ or ♏.x. Narcotic drugs should be given in only one-half the dose obtained by this rule for children are very susceptible to these drugs.

NEEDLE DOSAGE

Many medicaments at the present time are injected into the body by means of a syringe with a sharp hollow needle. Drugs are prepared for this purpose in the form of, (1) tablets that have been put up in a sterile manner, (2) sterile stock solutions, (3) ampules containing sterile drugs in either liquid or solid form. The drugs used for this purpose are usually the pure active principles of potent drugs, such as alkaloids and glucosides. Antitoxins and certain vaccines are also administered in this manner.

Table of Needle Dosage

Drugs	Metric (Gm.)	Apothecaries' (gr.)
Aconitine	0.00015	$\frac{1}{400}$
Atropine Sulphate	0.0005	$\frac{1}{120}$
Epinephrine	0.0005	$\frac{1}{120}$
Homatropine Hydrobromide	0.0005	$\frac{1}{120}$
Strophantin	0.0005	$\frac{1}{120}$
Thyroxin	0.0005	$\frac{1}{120}$
Hyoscyamine Hydrobromide	0.0006	$\frac{1}{100}$
Eserine Salicylate	0.002	$\frac{1}{30}$
Strychnine Sulphate	0.002	$\frac{1}{30}$
Apomorphine Hydrochloride	0.005	$\frac{1}{12}$
Pilocarpine Nitrate	0.005	$\frac{1}{12}$
Morphine Sulphate	0.008	$\frac{1}{8}$
Cocaine Hydrochloride	0.015	$\frac{1}{4}$
Emetine Hydrochloride	0.02	$\frac{1}{3}$
Codeine Sulphate	0.03	$\frac{1}{2}$
Sodium Cacodylate	0.06	1
Ephedrine Sulphate	0.06	1
Quinine Sulphate	0.1	$1\frac{1}{2}$
Caffeine Sodio-Benzoate	0.2	3

CALCULATION OF NEEDLE DOSES

Drugs administered by injection are usually given in doses which consist of small fractions of a grain or in some cases a small number of grains. If the drug is in the form of a tablet and the tablet on hand does not contain the dose required, the nurse must calculate the fractional part of a tablet, or the number of tablets, to use. If the drug is in the form of a stock solution and if a minim of the solution does not contain the dose prescribed the nurse must calculate the fractional part of a minim, or the number of minims, to administer.

If, for example, a 2 grain dose is to be given and only 3 grain tablets are on hand it is obvious that only $\frac{2}{3}$ of a 3 grain tablet may be administered. The arithmetic involved is *dividing the dose by the tablet.*

If a 1 grain dose is to be given from a stock solution in which a minim contains 2 grains it is evident that only $\frac{1}{2}$ of a minim may be given. The arithmetic involved is *dividing the dose by the strength of the stock solution* (the number of grains or fraction of a grain in one minim).

The following rule applies to the calculation of doses from either tablets or stock solutions: *Divide the required dose by the strength of the drug on hand.*

In popular phraseology, for convenience of remembering, it may be stated thus: Divide what you want by what you have.

Doses from Tablets

Technique for Obtaining the Dose. After the calculations have been made and the dose is a fraction of a tablet, it may be accurately obtained by dissolving a tablet in a given quantity of water and taking the amount indicated by the fraction. The following technique may be used: *If the answer is a fraction of a tablet, dissolve one tablet in a number of minims of water which can be divided evenly by the denominator of the fraction and take the amount indicated by the fraction.*

Examples:

(1) If you were directed to give a gr. $\frac{1}{60}$ dose of strychnine sulphate from tablets of gr. $\frac{1}{30}$, how would you prepare the dose?

$$\frac{1}{60} \div \frac{1}{30} = \frac{1}{60} \times \frac{30}{1} = \frac{1}{2}$$

The dose, therefore, is $\frac{1}{2}$ of a gr. $\frac{1}{30}$ tablet. To prepare this dose a tablet may be dissolved in 20 minims of water and $\frac{1}{2}$ of this, or 10 minims, used as the dose.

(2) A gr. $\frac{1}{6}$ dose of morphine sulphate is to be given from tablets of gr. $\frac{1}{8}$. How would you prepare the dose?

$$\frac{1}{6} \div \frac{1}{8} = \frac{1}{6} \times \frac{8}{1} = \frac{8}{6} = 1\frac{1}{3}$$

To give $1\frac{1}{3}$ tablets to the patient it is necessary to obtain the fractional part first. This may be done by dissolving one tablet in 30 minims of water and taking $\frac{1}{3}$ or 10 minims, and then dissolving another tablet in the 10 minims. The 10 minims will then contain the equivalent of $1\frac{1}{3}$ tablets of the drug.

Doses from Stock Solutions

The concentration of the stock solution is expressed either in percentage or as the number of minims which contain a certain dose, as ♏.x = gr. $\frac{1}{8}$. When the strength is expressed in percentage, the percentage strength written as a fraction is used as the strength of the drug on hand, in calculating doses. The percentage strength written as a fraction is the fraction of a grain in one minim. Thus in a 1 per cent solution any part of the solution contains $\frac{1}{100}$ of the drug and, therefore, each minim contains $\frac{1}{100}$ of the drug or $\frac{1}{100}$ of a grain of the drug (assuming that a minim weighs a grain). If the strength is expressed as the number of minims which contain a certain dose, then the fraction of a grain in one minim must be determined. If, as in the example above, 10 minims contain $\frac{1}{8}$ of a grain of the drug, then 1 minim contains $\frac{1}{10}$ of $\frac{1}{8}$ or $\frac{1}{80}$ of a grain. The strength of the drug on hand, therefore, in this case is $\frac{1}{80}$ grain.

Technique for Obtaining the Dose: *If the answer is a fraction of a minim, dissolve one minim of the stock solution in a number of minims of water so that the total number of minims can be divided evenly by the denominator, and take the amount indicated by the fraction.*

Examples:

(1) From a 0.5 per cent solution of aconitine prepare a gr. $\frac{1}{400}$ dose.

$$\frac{1}{400} \div \frac{.5}{100} = \frac{1}{400} \times \frac{100}{.5} = \frac{100}{200} = \frac{1}{2}$$

The dose, therefore, is $\frac{1}{2}$ of a minim. To prepare this dose a minim of the stock solution is dissolved in a suitable quantity of water, such as 19 minims. This gives a total of 20 minims of which $\frac{1}{2}$ or 10 minims is taken as the dose.

(2) Prepare a gr. $\frac{1}{8}$ dose of cocaine hydrochloride from a solution in which 10 minims contain gr. $\frac{1}{2}$.

$$\text{If } ♏.\text{x} = \text{gr. } \tfrac{1}{2} \text{ then } ♏\text{i} = \tfrac{1}{10} \text{ of } \tfrac{1}{2} \text{ or gr. } \tfrac{1}{20}$$

$$\tfrac{1}{8} \div \tfrac{1}{20} = \tfrac{1}{8} \times \tfrac{20}{1} = \tfrac{20}{8} = 2\tfrac{1}{2}$$

To give $2\frac{1}{2}$ minims to the patient it is necessary to obtain the fractional part first. This may be done by dissolving one minim of the stock solution in 19 minims of water, which gives a total of 20 minims, and taking $\frac{1}{2}$ of this, or 10 minims. To these 10 minims, 2 minims of stock solution are added. Thus a solution is obtained which contains $2\frac{1}{2}$ minims of the stock solution.

PROBLEMS

Each problem should be solved according to the rule, and if the answer is a fraction of a tablet or minim of stock solution, the technique necessary in preparing the dose for the patient should be given.

Doses from Tablets

1. How would you prepare a gr. $\frac{1}{400}$ dose of aconitine if only gr. $\frac{1}{200}$ tablets were available?

2. If you were directed to give gr. $\frac{1}{150}$ of atropine sulphate from
1/2 gr. $\frac{1}{100}$ tablets, how would you prepare the dose?

3. Give a gr. $\frac{1}{12}$ dose of apomorphine hydrochloride from gr. $\frac{1}{10}$ tablets.

4. Calculate how much of a gr. $\frac{1}{2}$ tablet of cocaine hydrochloride is needed to prepare a gr. $\frac{1}{4}$ dose.

5. A gr. $\frac{2}{3}$ dose of codeine sulphate is to be prepared from gr. i tablets. Make the calculations and explain how the dose should be prepared.

6. If directed to give gr. $\frac{1}{120}$ from gr. $\frac{1}{100}$ tablets of digitoxin, how would you prepare the dose?

7. Determine the number of gr. $\frac{1}{120}$ tablets of hyoscyamine hydrobromide needed to make a gr. $\frac{1}{100}$ dose.

8. Prepare a gr. $\frac{1}{120}$ dose of strophantin from gr. $\frac{1}{150}$ tablets.

9. How much of a gr. $\frac{1}{10}$ tablet of pilocarpine nitrate is needed to make a gr. $\frac{1}{12}$ dose?

10. Give strychnine sulphate gr. $\frac{1}{40}$ from gr. $\frac{1}{15}$ tablets.

11. A gr. $\frac{1}{100}$ dose of thyroxin is to be prepared from gr. $\frac{1}{60}$ tablets What part of a tablet is needed?

12. Calculate how much of a gr. $\frac{1}{150}$ tablet of hyoscine hydrobromide is needed to make a gr. $\frac{1}{100}$ dose.

13. How would you give a gr. $\frac{1}{8}$ dose of morphine sulphate from tablets of gr. $\frac{1}{2}$?

14. Prepare a gr. $\frac{1}{3}$ dose from gr. $\frac{1}{5}$ tablets of emetine hydrochloride.

15. A gr. $\frac{1}{250}$ dose of nitroglycerin is to be given from tablets of gr. $\frac{1}{50}$. How should the dose be prepared?

16. Determine how much of a gr.iii tablet is needed to make a gr.ii dose.

17. If you were directed to give a gr. $\frac{1}{120}$ dose of thyroxin from tablets of gr. $\frac{1}{100}$, how would you prepare the dose?

18. How much of a gr.iii tablet of sodium cacodylate is needed to obtain a gr.iss dose?

19. How should a gr. $\frac{1}{30}$ dose of strychnine sulphate be prepared from gr. $\frac{1}{40}$ tablets?

20. Calculate how much of a gr. $\frac{1}{2}$ tablet of codeine phosphate is needed to make a gr. $\frac{1}{5}$ dose.

Doses from Stock Solutions

1. How much of a 1 per cent stock solution of thyroxin is needed to prepare a gr. $\frac{1}{120}$ dose?

2. If directed to give a gr. $\frac{1}{120}$ dose of atropine sulphate from a $\frac{1}{2}$ per cent solution, how would you prepare the dose?

3. Each 10 minims of a solution of strychnine sulphate contain $\frac{1}{30}$ grain. How would you give a dose of $\frac{1}{140}$ grain?

4. Determine how much Magendie's solution (1:30) is needed to make a gr. $\frac{1}{4}$ dose of morphine.

5. From a solution of cocaine hydrochloride in which ♏.x = gr. $\frac{1}{2}$, prepare a gr. $\frac{1}{8}$ dose.

6. Caffeine sodio-benzoate is to be given in a gr.iiss dose. How would you prepare this dose from a 25 per cent solution?

7. How much of a 2 per cent solution of morphine sulphate is needed to obtain a gr. $\frac{1}{8}$ dose?

8. Calculate how much of a $\frac{1}{2}$ per cent solution of eserine sulphate is needed to make a gr. $\frac{1}{60}$ dose.

9. If ♏.x = gr. $\frac{1}{40}$ of atrophine sulphate, how many minims will be required to make a gr. $\frac{1}{60}$ dose?

10. Determine how much of a 5 per cent solution of codeine sulphate is needed to give a gr $\frac{1}{2}$ dose.

11. Each 10 minims of a solution contains $\frac{1}{10}$ grain of hyoscyamine hydrobromide. How much is needed to make a $\frac{1}{120}$ grain dose?

12. How much of a solution of pilocarpine nitrate in which ♏ x = gr iss is needed to make a gr. $\frac{1}{5}$ dose?

13. From a 0.5 per cent solution of strophantin prepare a gr. $\frac{1}{120}$ dose.

14. Calculate the number of minims of a 5 per cent solution of emetine hydrochloride needed to make a gr. $\frac{1}{3}$ dose.

15. If ♏.x = gr. ij of sodium cacodylate, how many minims will be required to prepare a gr. $\frac{1}{2}$ dose?

16. Determine how much of a solution of morphine hydrochloride, in which each 10 minims contain 2 grains, is required to prepare a $\frac{1}{4}$ grain dose.

✓ 17. In a solution of codeine phosphate ♏.x = gr.iiss. How much is needed to give a gr. $\frac{1}{5}$ dose?

18. How much of a 1 per cent solution of nitroglycerin is needed to make a $\frac{1}{250}$ grain dose?

19. If directed to give gr. $\frac{1}{400}$ of aconitine from a 0.5 per cent solution, how would you prepare the dose?

20. Determine the number of minims of a 2 per cent solution of pilocarpine hydrochloride needed to make a gr. $\frac{1}{12}$ dose.

Doses for Children

1. The adult dose of santonin is gr.iv; what is the dose for a 4 year old child?

2. If the adult dose of a drug is 5 grains, how much should be given a child 8 years old?

3. Calculate the dose of Fowler's solution for a child 12 years old. The adult dose is 3 minims.

4. The adult dose of tincture of aconite is ♏.v; what is the dose for a 13 year old child?

5. Considering that narcotics should be given children in half the proportionate amounts for adults, calculate the dose of morphine sulphate for a 6 year old child. The adult dose is 5 mg.

6. If the adult dose of a drug by mouth is gr.i, what is the hypodermic dose for a child 8 years old?

7. The adult dose of castor oil is 16 cubic centimeters. What is the dose for a 4 year old child?

8. What is the dose of fluidextract of gentian for a 3 year old child? The adult dose is gr.x.

9. The adult dose of licorice powder is 3 grams; what is the dose for a child 6 years of age?

10. What is the dose of calomel for a child 6 months old, the adult dose being 0.3 gram.

SOLUTIONS FOR NEEDLE ADMINISTRATION

Atropine Sulphate Solution

Atropine sulphate	0.065
Physiological solution of sodium chloride, to make	100 cc.

Dose: 1 cc.

Calcium Cacodylate Solution

Calcium cacodylate	5 Gm.
Sterile distilled water, to make	100 cc.

Dose: 1 cc.

Dextrose Solution

Dextrose, anhydrous	500 Gm.
Sterile distilled water, to make	1000 cc.

Dose: 50 cc.

Magendie's Solution

Morphine sulphate	1 Gm.
Sterile distilled water, to make	30 cc.

Dose: 0.25 cc.

Magnesium Sulphate Solution

Magnesium sulphate	100 Gm.
Sterile distilled water, to make	200 cc.

Dose: 2 cc.

Procaine Hydrochloride Solution

Procaine hydrochloride	2 Gm.
Sterile distilled water, to make	100 cc.

Dose: 1 cc.

Sodium Bicarbonate Solution

Sodium bicarbonate	50 Gm.
Sterile distilled water, to make	1000 cc.

Dose: 20 cc.

Sodium Chloride Solution (Concentrated)

Sodium chloride	85 Gm.
Sterile distilled water, to make	1000 cc.

Note: To make physiological salt solution dissolve 50 cc. of the above solution in 450 cc. of sterile distilled water.

Sodium Citrate Solution (for Blood Transfusion)

Sodium citrate	10 Gm.
Physiological salt solution, to make	1000 cc.

Sodium Iodide Solution

Sodium iodide	100 Gm.
Sterile distilled water, to make	1000 cc.

Dose: 20 cc.

Sodium Thiosulphate Solution

Sodium thiosulphate	100 Gm.
Sterile distilled water, to make	1000 cc.

Dose: 10 cc.

Strychnine Sulphate Solution

Strychnine sulphate	0.1 Gm.
Physiological salt solution, to make	100 cc.

Dose: 1 cc.

Questions for Class Discussion

1. Define: (a) dose, (b) dosage, (c) posology (d) minimum dose, (e) maximum dose, (f) toxic dose, (g) lethal dose.

2. Name and discuss the factors which determine the dose.

3. How do the doses of fluidextracts, tinctures, and extracts compare with that of the crude drug?

4. Why may some drugs be administered more frequently than others?

5. Give the approximate apothecaries' and metric equivalents of the following domestic measures: (a) teaspoonful, (b) dessertspoonful, (c) tablespoonful, (d) tumblerful.

6. Consulting the table of needle dosage make a table of the metric equivalents of the following:

gr.iii
gr.iss
gr.i
gr. $\frac{1}{2}$
gr. $\frac{1}{3}$
gr. $\frac{1}{4}$
gr. $\frac{1}{8}$
gr. $\frac{1}{12}$
gr. $\frac{1}{30}$
gr. $\frac{1}{100}$
gr. $\frac{1}{120}$
gr. $\frac{1}{400}$

7. State the rule for ascertaining the dose for children.

8. In what forms are drugs put up for needle administration?

9. State the rule for the calculation of needle doses.

10. Give the technique for preparing the dose when it is a fraction of a tablet.

11. Give the technique for preparing the dose when it is a fraction of a minim.

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CHAPTER XVI

ADMINISTRATION OF MEDICINES

Administration for Local Effects.
- Application to the Skin.
- Application to Mucous Membranes.
- Application to Wounds.
- Application of Local Anesthetics.

Administration for Systemic Effects.
- By Mouth.
- Needle Medication.
- Inunction.
- Inhalation.
- Rectal Administration.

The term *administration* applied to medicines refers to the manner in which they are applied to, or introduced into, the body. The channels used for the administration of medicines vary according to whether the action is to be local or systemic. Local applications are made to the skin, mucous surfaces, and wounded tissues. A number of channels are available for the systemic administration of medicines. They may be given by, (1) mouth, (2) rectum, (3) rubbing into the skin, or (4) injection under the skin, into muscles, or directly into the blood stream.

ADMINISTRATION FOR LOCAL EFFECTS

Application to the Skin.—Medicines are applied to the skin to, (1) act on the surface (epidermic action), or (2) to act on the derma (endermic action). When *epidermic* action is desired the medicament may be in the form of aqueous solutions, moist dressings, ointments, cerates, or dusting powders.

When *endermic* action is desired the drug must penetrate the layer of dead keratinized cells on the surface as well as the fatty secretion (sebum) of the sebaceous glands, which covers the skin. This type of action is usually produced with liniments, alcoholic solutions, or ointments. The best ointment base for this purpose is lanolin (hydrous wool fat). Fatty substances applied to the skin prevent the evaporation of sweat. This softens the epidermis and increases the size of the spaces between the cells and permits the passage of the drug through the epidermis into the dermis. Petrolatum, which is commonly used in making ointments, does not penetrate the skin well. The friction used in applying liniments tends to force the drug into the sebaceous ducts and hair follicles, and thus favors penetration.

Application to Mucous Membranes.—Since mucous membranes are constantly covered by watery secretions, oily liquids are not well suited for their medication, but aqueous solutions are readily absorbed. Antiseptic and astringent solutions are generally employed to medicate mucous surfaces. To medicate the mouth and pharynx lozenges, or solutions used as gargles, sprays, or mouth washes are employed. The nasal mucous membrane may be treated by douching, swabbing, spraying, or inhalation. Isotonic solutions are to be preferred since this membrane is very sensitive.

In the administration of drugs which are to act locally upon the stomach or intestine, it must be remembered that absorption into the blood stream may occur and thus a systemic effect may result. Certain drugs used for this purpose produce only local effects because of insolubility (bismuth subnitrate) or non-absorbability (magnesium sulphate). To obtain a maximum effect upon the mucous membrane of the stomach the drug should be administered when the stomach is empty, that is one-half to one hour before meals.

By means of a stomach-tube a remedy may be introduced into the stomach and withdrawn before absorption can occur. When the tube has entered the stomach the medicine is poured into the funnel at the end of the tube. The funnel is then rapidly lowered below the level of the patient's stomach, which is thus drained by siphonage. Washing out the stomach by means of a stomach-tube is known as *gastric lavage.*

For local action in the intestine the drug should be given two or three hours after meals when the contents of the stomach are being emptied into the duodenum. To prevent action on the stomach the drug may be given in the form of pills coated with keratin or salol which are insoluble in the acid contents of the stomach but soluble in the alkaline fluids of the intestine. Sometimes a duodenal tube is used to avoid action of the drug on the stomach. Rapidly acting cathartics, such as magnesium sulphate, are best given in the morning before food is taken, while slowly acting cathartics are usually administered at night.

Drugs may be introduced into the rectum for local medication or to produce bowel movement. Suppositories and enemas are used for these purposes. The genito-urinary organs may be medicated in various ways. The urethra may be treated with injections, irrigations or bougies (urethral suppositories). The urinary bladder is usually medicated by irrigation by means of a soft rubber catheter. The vagina may be treated with suppositories, tampons, or douches. Inhalation may be resorted to for local action on the respiratory tract to treat catarrhal and other inflammatory conditions. The medicament may be in the form of a gas, steam (drug evaporated with steam), vapor, spray, or smoke (burning the drug and inhaling the smoke).

Application to Wounds.—Wounds may be treated with wet dressings, pastes, continuous irrigation, dusting powders, or detergent solutions. Certain drugs are absorbed readily by wounds and may give rise to undesirable systemic effects.

Application of Local Anesthetics.—Local anesthetics are applied to, or injected into, tissue to paralyze sensory nerves so that operations may be performed without pain. Usually epinephrine is included to restrict the local circulation so that absorption of the anesthetic will be retarded.

ADMINISTRATION FOR SYSTEMIC EFFECTS

By Mouth.—This is the method most frequently used and is the most convenient. Liquids, powders, pills, tablets, and capsules may be given in this way. Very little absorption occurs from the stomach. Drugs given by mouth are absorbed chiefly from the intestine, although highly volatile drugs may be absorbed from the tongue. When rapid absorption is desired the drug may be given in solution when the stomach is empty. It will then pass into the intestine in a very short time. When a drug is given immediately after a meal it may remain in the stomach a few hours before entering the intestine. A drug that has an irritant action on the stomach is best given after meals. The mixing of the drug with the meal reduces its local effect. If the drug is to give continued action it may be given three times a day after meals. Drugs which may interfere with digestion should be given about two or three hours after meals.

There are certain factors that influence the absorption of drugs. A drug that is soluble in water is usually more readily absorbed than one that is not. An insoluble drug may go into solution by means of chemical changes in the stomach or intestine. Oils are saponified and thus made soluble in the intestine, while certain insoluble metallic salts are converted into soluble chlorides by the hydrochloric acid of the gastric juice.

Some drugs are destroyed in the stomach or intestine and consequently are not effective when administered orally. This is true of arsphenamine, insulin, epinephrine and the various antitoxins. Drugs absorbed from the intestine pass through the liver before reaching the general circulation. In the liver they are often changed or even destroyed. Some never reach the general circulation but are excreted from the liver with the bile.

Medicines given by mouth are usually diluted before being given to the patient. This improves the taste (except those of very disagreeable taste) and tends to prevent irritation of the stomach. To prevent nausea or vomiting the drug may be diluted with ice cold water, lemon juice, or carbonated water. Iron in solution and the mineral acids are liable to injure the enamel of the teeth and should be given through a straw or glass tube.

Some drugs may be given by placing them under the tongue to be absorbed into the general circulation. This method is suitable only for drugs that are given in very small doses as a few minims or a hypodermic tablet. This method is known as *sublingual* administration. Absorption takes place very quickly from the mucous membrane under the tongue.

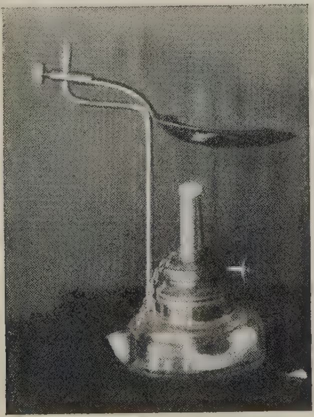

FIG. 27.—Hypodermic spoon and lamp.

Needle Medication.—In this type of medication a syringe with a hollow needle is used to inject the medicament into the body tissues. The needle, syringe, and medicine must be sterile and the skin of the patient at the point where the injection is to be made should be washed with soap and water and then sponged with 70 per cent alcohol or painted with tincture of iodine. Before the injection is made the air from the syringe should be expelled. The hands of the nurse should be surgically clean.

Only medicines given in small doses are administered by injection. The dose of a drug given by this method is usually one-fourth to one-half of the oral dose. The drugs used may be in the form of sterile stock solutions, tablets, or ampules. In preparing a dose from a tablet, a small amount of water is heated in a spoon over an alcohol lamp or gas-burner and then drawn into a sterile syringe. A tablet is shaken from the vial into the empty sterile spoon and the syringe is emptied into the spoon to dissolve the tablet. The solution is then drawn into the syringe. The air is removed from the needle by holding the syringe in a vertical position with the needle pointing upward and pushing on the piston until a droplet escapes from the needle tip.

The injection method has advantages over other methods in that; (1) the dose may be gauged accurately since all of the drug gets into the blood stream; (2) the action is prompt and certain; (3) gastric irritation is avoided; (4) certain drugs which are ineffective when given by other methods, give prompt results by this method.

The following methods of injection are used: (1) hypodermic (subcutaneous), (2) intramuscular, (3) intravenous, (4) intraspinal, (5) hypodermoclysis (hypodermic infusion), and (6) intravenous infusion.

Hypodermic Injection.—This is also known as subcutaneous injection and is made into the loose tissue beneath the skin. In making the injection a fold of the skin is raised with the fingers while the needle is pushed firmly through the skin into the middle of the fold. The injection should be slow but continuous, in order that it may be as painless as possible. Rapid injection causes a violent disruption of the loose subcutaneous tissues. After withdrawing the needle the part is gently massaged. Hypodermic injections are generally given into the outer surfaces of the arm or thigh.

Intramuscular Injection —In this method the injection is made through the skin and subcutaneous tissue into the underlying muscles, usually in the buttock. The skin is stretched with the fingers and the needle inserted perpendicularly. Great care must be taken to avoid injecting the drug into blood vessels. To make sure that the point of the needle is not in a blood vessel the plunger is drawn out a little and if blood is aspirated into the syringe the needle must be withdrawn and reinserted at another place. The fluid is slowly injected and the needle quickly withdrawn. The area is then gently massaged to promote the diffussion of the liquid into the surrounding tissues.

This method is used when the drug has an irritant action when injected subcutaneously. It has the advantage of very rapid absorption and less liability to abscess formation. Diphtheria and tetanus antitoxins, insoluble salts of mercury, emetine, and bismuth preparations are examples of drugs administered by this method.

Intravenous Injection.—In recent years it has been found that many drugs may be given with safety by the intravenous route. The injection is usually made into one of the veins at the bend of the elbow. A tourniquet is placed above the elbow to distend the vein so that it can be found more readily. The needle is introduced into the vein in a slanting direction toward the heart. As soon as the needle enters the vein blood will flow into the syringe or a few drops may be aspirated into the syringe to make sure that the tip of the needle is in the vein. The tourniquet is then removed and the medicine is slowly injected. It takes from 5 to 15 minutes for the injection depending upon the quantity of medication injected.

The intravenous method is used when; (1) the drug is too irritating to administer by the subcutaneous or intramuscular method; (2) when the circulation is very feeble and absorption, therefore, very slow; (3) when immediate action is necessary. Examples of drugs administered by this method are arsphenamine, epinephrine, sodium iodide, sodium salicylate, methenamine, and iron cacodylate.

Intraspinal Injection.—Before the drug is injected a puncture is made between the third and fourth lumbar vertebrae, with a needle, into the spinal canal. A quantity of cerebro-spinal fluid equivalent to the amount of medicament to be introduced, is withdrawn. The medicine is then introduced. The intraspinal method is resorted to in the administration of meningococcus antiserum, tetanus antitoxin, arsphenamine in neuro-syphilis, and anesthetics for the production of spinal anesthesia.

Hypodermoclysis.—This refers to the administration of fluid, usually physiological salt solution, by injection into the subcutaneous tissues of the breast or abdomen. Instead of a syringe a glass irrigator with rubber tubing is used. About one liter of sterile solution is infused at a time.

Intravenous Infusion.—In intravenous infusion a large quantity of solution (500 to 1500 cc.) is introduced into the bloodstream. Instead of a syringe a graduated glass reservoir with rubber tubing and needle are used. Examples of solutions administered in this manner are dextrose (glucose), sodium bicarbonate, Locke-Ringer's solution, epinephrine in saline solution, and physiological salt solution. Solutions used for infusion should be isotonic with the blood and should be warm (about 110°F.) when used. Infusion is resorted to in conditions of severe toxemia, such as uremia, septicemia, and diabetic coma, and also to combat the low blood pressure of collapse. In hemorrhage it may be used to restore the volume of blood lost.

Inunction.—Drugs are at times applied to the skin to produce systemic effects after absorption into the blood stream. Drug action resulting from this type of medication is known as *diadermic* action. When the drug is in the form of an ointment and applied to the skin with friction, the method of application is known as *inunction.* The best ointment bases for this purpose are lard and wool fat. When applied where the skin is thin some of the drug penetrates the skin and is absorbed into the blood stream. It is not a quick method and is rather uncertain since it is impossible to determine how much of the drug will penetrate and enter the blood stream.

Mercury is applied by inunction in the treatment of syphilis. As mercury irritates the skin it is customary to use various areas of the skin in regular sequence on consecutive days. Iodine may also be employed in this way.

Inhalation.—Certain volatile drugs are administered by inhalation and are readily absorbed by the blood stream from the extensive surface of the lungs. The inhalation of ammonia fumes stimulates the respiratory center and the heart. It may be administered in the form of aromatic spirit of ammonia or smelling salts which consist of ammonia, rock salt crystals, and an aromatic substance. The inhalation of amyl nitrate causes a dilation of the arteries, thus lowering the blood pressure. Drugs, such as ether, chloroform, and nitrous oxide, which are used to produce general anesthesia are also administered by this method.

Rectal Administration.—When it is necessary to administer a drug by rectum for systemic effects the dose is usually twice that which would be required by mouth, with the exception of certain alkaloids such as morphine and strychnine in which the dose is smaller than by mouth. This method is used when it is not advisable to resort to the use of the needle or when the stomach will not retain the medicine. The medicaments are used in the form of enemas, suppositories, or fluids administered by proctoclysis.

Proctoclysis refers to the administration of fluid into the rectum by means of the Murphy drip method which consists of giving a warm physiological salt solution at the rate of 40 to 60 drops per minute for a period of hours or even days. It is employed in the treatment of perforative peritonitis, septicemia, shock, and after abdominal operations.

Questions for Class Discussion

1. Name the various channels available for the administration of medicines.

2. To what parts of the body are drugs applied for local effects?

3. Define: (a) epidermic action, (b) endermic action.

4. Name pharmaceutical preparations used in epidermic and endermic medication.

5. Which ointment base is best suited for endermic action?

6. In what forms are drugs used to medicate mucous membranes?

7. How may the mouth and throat be medicated?

8. Discuss medication of, (a) the stomach, and (b) the intestine.

9. What is meant by gastric lavage?

10. Name preparations used to medicate, (a) the rectum, (b) the urethra, (c) the bladder, (d) the vagina.

11. Give methods of applying drugs to the lungs for local action.

12. Name preparations suitable for application to wounds.

13. Give the various methods of administering drugs for systemic effects.

14. From what part of the alimentary tract does the absorption of medicine chiefly occur?

15. Why is absorption more rapid if the drug is given when the stomach is empty?

16. Why is it best to give a drug which has an irritant action on the stomach, after meals?

17. At what time, in relation to meals, should a drug which may interfere with digestion be given?

18. What chemical changes may occur in drugs in the stomach or intestine?

19. Name drugs that are destroyed in the stomach.

20. What effect may the liver exert on drugs?

21. Why are drugs given by mouth usually diluted?

22. How should a drug which has a tendency to produce nausea or vomiting, be administered by mouth?

23. What is meant by sublingual administration?

24. Which method of administration results in the quickest action of a drug?

25. How does the needle dose compare with the oral dose?

26. Describe the general method of needle administration.

27. What advantages does the injection method have over other methods?

28. Describe the following methods of injection: (a) hypodermic, (b) intramuscular, (c) intravenous, (d) intraspinal, (e) hypodermoclysis, and (f) intravenous infusion.

29. Describe the process of giving a drug by inunction.
30. Name drugs given by inhalation to produce systemic effects.
31. How does the rectal dose compare with that given by mouth, when systemic effects are desired?
32. Describe proctoclysis.

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CHAPTER XVII

TOXICOLOGY

Types of Poisons.
Recognition of Poisoning.
General Treatment of Poisoning.
Corrosive Poisoning.
Poisoning by Metallic Salts.
Poisoning by Alkaloids and Other Potent Drugs.

A drug may destroy life or seriously endanger health when administered in an improper manner or in too large a dose. Under such conditions it becomes a *poison.* The difference between a medicine and a poison is quantitative rather than qualitative. The study of the symptoms and treatment of poisoning is known as *toxicology.*

Poisoning may be of two kinds, (1) *chronic* and, (2) *acute.* Chronic poisoning occurs from repeated doses of a drug which has the tendency of accumulating in the body. Acute poisoning is due to a single dose which produces sudden and alarming symptoms such as vomiting, convulsions, and collapse.

TYPES OF POISONS

In regard to their poisonous actions drugs may be classified as (1) corrosive, (2) irritant, and (3) neurotic poisons. *Corrosives* are agents which cause a direct destruction of the tissues they come in contact with. They consist chiefly of the mineral acids and strong alkalies. Phenol is also included in this group. It is chiefly upon the mucous membrane of the alimentary tract that their corrosive effect is produced. They give rise to a burning pain in the mouth, throat, and stomach. Nausea, vomiting, and diarrhea occur. The skin becomes cold and clammy, the pulse rapid, feeble and irregular. Breathing becomes rapid but superficial.

Irritant poisons produce inflammation without direct destruction of tissue. The action is local and is caused chiefly by the metallic salts. Abdominal pain, nausea, vomiting, and diarrhea occur. *Neurotic poisons* produce systemic effects by acting upon the central nervous system. The general symptoms are restlessness and nervous excitement followed by delirium, convulsions, and sometimes coma. Breathing is rapid, the skin is hot and dry, and the face flushed. Muscular twitchings, vomiting, and diarrhea may occur.

RECOGNITION OF POISONING

When alarming symptoms develop rather suddenly, poisoning may be suspected. If the poison is unknown it may be possible to determine the type of poison by the symptoms of the patient. When poisoning is caused by an *acid* the lips become dry, shrunken, and white or yellow in color. The vomitus contains blood and pieces of mucous membrane.

In poisoning by *caustic alkalies* a swollen white crust occurs around the mouth. The vomitus is similar to that in acid poisoning. In phenol poisoning the lips and mouth become blanched and there is an odor of phenol on the breath. A very characteristic indication of phenol poisoning is the dark-green color of the urine.

In poisoning by the *metallic salts* the indications are, burning pain in the mouth, severe abdominal pain, and a grayish white membrane in the mouth, which occurs especially in silver poisoning. Lead poisoning may be recognized by a blue line along the margin of the gums (lead line).

In *neurotic poisoning* the diagnosis is based upon the symptoms displayed by the patient. It is often difficult to distinguish this type of poisoning from certain diseases.

GENERAL TREATMENT OF POISONING

Although each kind of poisoning requires specific treatment, the general treatment does not vary greatly with drugs of the same class. Prompt action is very important in all types of poisoning. A physician should be summoned at once in each case. The stomach should be emptied excepting in cases of corrosive poisoning. This may be done by gastric lavage or with emetics. It is not always necessary to take this step since the poison itself may act as an emetic. When the poisoning has been due to an acid, alkali, or to phenol, gastric lavage and emetics are *contraindicated.* Any one of the following emetics may be used:

Zinc sulphate, 20 grains in half a glass of warm water.
Mustard, a teaspoonful in a glass of warm water.
Apomorphine hydrochloride, $\frac{1}{10}$ grain hypodermically.
Ipecac, 30 grains in half a glass of warm water.

After the stomach has been emptied the appropriate antidote (if there is one for the poison concerned) is given. An *antidote* is an agent which combines chemically with the poison and either lessens or destroys its action. Since antidotes combine chemically with poisons they may be called *chemical antidotes* to distinguish them from *antagonists* which are sometimes called *physiological antidotes.* Acids are antidotes for alkalies and vice versa. Magnesium sulphate (or sodium sulphate) is the antidote for phenol poisoning, albumin (egg white) for poisoning by mercury salts, and sodium chloride for silver salts.

Some general antidotes have been devised for use when the nature of the poison is unknown. One of these consists of one part each of tannic acid and magnesium oxide, and two parts of powdered charcoal. It is known as the *universal antidote* and the dose is a heaping teaspoonful in half a glass of warm water repeated in fifteen to twenty minutes if necessary. The tannic acid precipitates certain toxic substances and neutralizes alkalies, magnesium oxide neutralizes acids and precipitates many poisons, and the charcoal absorbs poisons.

A rapidly acting *cathartic,* such as castor oil or Epsom salt is usually given after the chemical antidote to remove the compounds formed, from the intestinal tract. To soothe and protect the mucous membrane of the throat, esophagus, and stomach a *demulcent* is generally administered. Common demulcents used are raw eggs, milk, a mixture of four eggs in a pint of milk, milk and flour, starch paste, mucilage of acacia and olive or salad oil.

To aid in the elimination of the poison that may have been absorbed by the blood stream, physicians administer *diaphoretics* and *diuretics.* To counteract the systemic effects of the absorbed poison the appropriate *antagonist* is given. This usually consists of a hypodermic injection of a drug to counteract shock and vital depression. Strychnine is used to stimulate the respiratory center when this has been depressed by the poison, and atropine is given to maintain the action of the heart until the poison has been eliminated. The patient must be kept warm and the pain may be mitigated with morphine.

TREATMENT OF CORROSIVE POISONING

Mineral Acids.—1. Do not use a stomach tube or emetics. The stomach tube may cause perforations of the softened stomach and esophagus.

2. Neutralize the acid by giving one of the following:

(a) Magnesium oxide, several tablespoonfuls in water. This is the best antidote.
(b) Soap solution, castile soap dissolved in four volumes of water.
(c) Milk of magnesia.
(d) Washing soda.
(e) Aromatic spirit of ammonia, a teaspoonful in a glass of water.
(f) Chalk.
(g) Plaster from the wall.

3. Give one of the following demulcents; (a) raw eggs, (b) milk and flour, (c) acacia, (d) olive or salad oil.

4. Shock and pain may be treated with morphine sulphate (gr. $\frac{1}{3}$ hypodermic).

5. To stimulate the vital forces, hypodermic injections of digitalis preparations, atropine and strychnine are given.

Caustic Alkalies.—1. Do not use stomach tube or emetics for the danger of perforations is very great.

2. Neutralize the alkali by giving one of the following:

(a) Vinegar diluted with an equal quantity of water.
(b) Acetic acid, 5 per cent.
(c) Lemon juice.

3. Give olive oil, salad oil, or butter to form soaps with the alkali.

4. Treat the shock and pain with morphine sulphate.

5. Administer general stimulants.

Phenol.—1. Use stomach tube with care and wash out the stomach with alcohol diluted with an equal quantity of water. Alcohol has a dissolving action on phenol and thus keeps it from penetrating the tissues in concentrated form. Alcohol must not be given as a drink unless it is followed by an emetic, preferably mustard.

2. Give magnesium or sodium sulphate (antidote), one ounce in a half pint of water. This forms sulphophenolate which is harmless.

3. Administer one of the following demulcents; (a) raw eggs, (b) milk and flour, (c) acacia.

Note: Oils should not be given as they promote the absorption of phenol.

4. Treat the shock and pain with morphine and atropine sulphate (hypodermic). Atropine exerts an antagonist effect on the systemic symptoms. By these measures the actions of the heart and respiration may be maintained until the poison has been eliminated.

5. Apply heat to the extremities.

POISONING BY METALLIC SALTS

Lead Poisoning (Acute).—1. Use stomach tube or emetic.

2. Give magnesium sulphate (antidote), one-half ounce in a tumblerful of water.

3. Give raw eggs or white of egg.

4. Treat shock and pain with morphine sulphate.

5. Administer general stimulants.

6. Treat lead colic with hot-water bag.

Mercury Poisoning.—1. Give large quantity of raw eggs in milk or water (one egg to each four grains of the poison) before emptying the stomach.

2. Empty stomach with stomach tube or emetic.

3. Give potassium citrate, 15 grains, every two hours alternately with magnesium sulphate, 1 dram.

4. Give tannic acid, strong coffee or tea.

5. Treat shock and pain with morphine sulphate.

6. Administer stimulants and give large draughts of water.

7. Keep patient warm with hot packs.

8. Potassium iodide may be used as an after treatment. It helps to eliminate the poison from the tissues.

Silver Poisoning.—1. Give two tablespoonfuls of table salt (antidote) in a tumblerful of water. This converts the silver salt into insoluble chloride of silver.

2. Give an emetic.

3. Administer a demulcent.

4. To move the bowels give castor oil.

Zinc Poisoning.—1. Do not use stomach tube or emetic, because of corrosion of membranes.

2. Give large quantities of raw eggs and milk.

3. Give sodium or potassium carbonate, one teaspoonful in warm water. This converts the zinc into insoluble zinc carbonate.

4. Administer tannic acid or strong tea. This converts the zinc into the slowly soluble tannate.

5. Treat shock and pain with morphine sulphate.

6. Apply hot applications to allay abdominal pain.

ALKALOIDS AND OTHER POTENT DRUGS

In poisoning by alkaloids, glucosides, arsenic, and other potent drugs each case must be treated individually. The toxicity of these drugs is due to systemic effects. To understand the treatment of poisoning by these drugs it is necessary to understand the actions of these drugs on the body. Since these drugs are considered later in the course of study of the student of nursing, their toxicology will not be considered here.

Questions for Class Discussion

1. Define: (a) toxicology, (b) poison, (c) chronic poisoning, (d) acute poisoning.
2. Differentiate between the following types of poisons: (a) corrosives, (b) irritants, (c) neurotic poisons.
3. Give the symptoms of poisoning by, (a) acids, (b) alkalies, (c) phenol, (d) metallic salts.
4. Distinguish between a chemical and physiological antidote.
5. Name the antidotes used in poisoning by, (a) mineral acids, (b) caustic alkalies, (c) phenol, (d) lead salts, (e) mercuric chloride, (f) silver nitrate, (g) zinc salts.
6. What does the universal antidote contain?
7. Name suitable emetics that may be used to empty the stomach.
8. Why are demulcents administered? Name suitable demulcents.
9. In which kinds of poisoning should the use of the stomach tube be avoided?
10. Give the general emergency treatment of poisoning.
11. What treatment is used to counteract shock and vital depression?
12. Give the emergency treatment of poisoning by, (a) mineral acids, (b) caustic alkalies, (c) phenol, (d) lead salts, (e) mercury salts, (f) silver salts, and (g) zinc salts.

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CHAPTER XVIII

LAWS RELATING TO DRUGS

Federal Food and Drugs Act.
Harrison Narcotic Law.
National Prohibition Act.
Vaccine and Serum Inspection.

FEDERAL FOOD AND DRUGS ACT

The Federal Food and Drugs Act was passed by Congress in 1906 and became effective in January 1907. The purpose of the provisions of this law that pertain to drugs, is to prevent the adulteration of crude drugs and medicinal preparations, and to make illegal the use of false or misleading statements on the labels of the containers in which drugs are sold. It provides that a medicament, sold under a name recognized in the United States Pharmacopœia or National Formulary, be made as prescribed in these books. Any deviation from the formula must be indicated on the label. These two books have thus become legal standards by this act.

A list of the ingredients need not be stated on the label but the presence and quantities of certain drugs, such as alcohol, opium, morphine, cocaine, chloroform, cannabis indica, chloral hydrate, and acetanilid must be indicated on the label. Labels are not permitted to contain false claims, exaggerated statements or, misrepresentations. By "label" is meant not only the label attached to the container but also any printed matter that may accompany the package.

This law applies to all drugs which enter interstate commerce but not drugs which are sold only within the State in which they are made. Most of the States have laws similar to the Federal Food and Drugs Act, which apply to drugs sold within the states.

HARRISON NARCOTIC LAW

The Harrison Narcotic Law of 1914 regulates the importation, manufacture, selling, and dispensing of opium and coca leaves and compounds, salts, derivatives and preparations thereof. This law aims to stamp out the wide-spread and destructive use of narcotics and thus limit their use to strictly medical purposes. The law provides that every person or firm importing, manufacturing, selling, dispensing, or prescribing these drugs, must register with the collector of internal revenue.

It is unlawful to sell these drugs to anyone except those registered under this law and then only when a special order blank, issued by the Commissioner of Internal Revenue, is used. Every buyer and seller must keep all orders on record for a period of two years for inspection. A physician who prescribes narcotic drugs must register and pay the tax even though he does not keep such drugs in his possession. A nurse need not register and is permitted to have narcotics in her possession only when she is working under the directions of a registered physician.

A prescription including narcotic drugs can be legally issued only for legitimate medical purposes. It is unlawful for a physician to issue a prescription to an addict or habitual user of narcotics, except in an attempted cure of the habit. The prescription must be correctly dated, bear the name and address of the patient and the name and address and registry number of the physician. The pharmacist must preserve all narcotic prescriptions, in a separate file, for a period of two years for inspection by official agents of the Treasury Department. It is unlawful for the pharmacist to refill the prescription.

Certain ready-made narcotic preparations compounded in accordance with the Pharmacopœia, National Formulary, or an established formula, are exempt from most of the above provisions. In order to be exempt they must contain not more than two grains of opium, or more than one-fourth grain of morphine, or more than one grain of codeine (or any derivatives of these), in one fluid ounce. They must contain active drugs other than narcotics and may be sold without a prescription but a record must be kept of the sale. An example of this type of preparation is Paregoric (Camphorated Tincture of Opium, *U.S.P.*), which contains not quite two grains of opium to the fluid ounce. There is no limitation upon the percentage of narcotics in medicaments for external use provided that they have been rendered unfit (denatured) for internal administration.

Those who violate the narcotic law in any particular are liable to a fine of not more than two thousand dollars, or to imprisonment for not more than five years, or both.

NATIONAL PROHIBITION ACT

This act, also known as the Volstead Act, prohibits the use of alcoholic intoxicants as beverages. It was enacted to enforce the provisions of the eighteenth amendment of the constitution of the United States. This law defines an intoxicating liquor as one which contains one-half of one per cent or more of alcohol. A physician who prescribes intoxicating liquor is required to obtain a permit from the Federal Prohibition Director. Upon receiving a permit he is provided with a book of one hundred authorized prescription blanks containing serial numbers. Not more than one book is issued to a physician in a period of ninety days.

A physician is permitted to prescribe intoxicating liquor only in cases where it is believed to be necessary to afford relief from some known ailment, and not more than one pint of distilled liquor or one quart of wine within a period of ten days. Each prescription must be correctly dated, contain the name of the patient to whom issued, the ailment for which prescribed and directions for its use including the amount and frequency of the dose. The prescription may not be refilled. All prescriptions for liquor must be written in duplicate and the physician must keep one copy and a record on a special form for this purpose. The pharmacist who fills the prescription must have a permit to handle and dispense liquor.

Hospitals may obtain liquor and alcohol under the provisions of this law but must keep a record of the amount used and purposes for which it was used. It may be used only upon prescription of hospital physicians.

Any person violating the provisions of this law must pay a fine of not more than five hundred dollars for the first offense; not less than one hundred dollars nor more than one thousand dollars, or be imprisoned not more than ninety days for the second offense; and for any subsequent offense a fine of not less than five hundred dollars or be imprisoned not more than two years.

VACCINE AND SERUM INSPECTION

The manufacture of antisera, toxins, and vaccines has been placed under the supervision of the United States Public Health Service. Manufacturers must obtain licences from the Public Health Service before they are permitted to sell these products. Inspection of establishments making these products are made regularly and samples of their products are examined to insure the observance of safe methods of manufacture, and to determine the purity and freedom from contamination by the tetanus bacillus or other pathogenic bacteria. If the product is one that has been standardized its potency is also determined.

Questions for Class Discussion

1. What is the purpose of the Federal Food and Drugs Act?
2. Give the chief provisions of this law, that pertain to drugs.
3. What is the purpose of the Harrison Narcotic Law?
4. Give the chief provisions of this law.
5. What is the status of the nurse under this law?
6. What are the provisions concerning exempt preparations?
7. Differentiate between the eighteenth amendment and the Volstead Act.
8. How does the National Prohibition Act define an intoxicating liquor?
9. What are the provisions concerning prescriptions for intoxicating liquor?
10. Give the legal requirements for the manufacture of antisera and vaccines?

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CHAPTER XIX

PROBLEMS FOR REVIEW

Weights and Measures.
Strength of Solutions.
Preparation of Solutions.
Preparation of Doses.

WEIGHTS AND MEASURES

1. Convert into grams: (a) 3000 mg., (b) 575 dg., (c) 35 cg., (d) 65 mg.

2. Convert into milligrams: (a) 5 Gm., (b) 10 dg., (c) 55 cg., (d) 75 dg.

3. Add and express in grams:

   (a) 5 Gm., 8 dg., 4 cg., 70 mg.
   (b) 65 mg., 25 Gm., 9 dg., 12 cg.

4. Add and express in milligrams:

   (a) 84 mg., 4 dg., 7 cg.
   (b) 7 dg., 3 cg., 45 mg.

5. Determine the number of grains in, (a) ʒij, (b) ℥ivss, (c) lb.i, (d) ʒviii.

6. Determine the number of minims in, (a) fʒvii, (b) f℥xvi, (c) Oiii, (d) f℥ix.

7. Change, (a) 2 pints to drams, (b) 3 quarts to ounces, (c) 1 pint, 7 ounces to minims.

8. Change to higher denominations: (a) 18 ounces, (b) 24 fluidounces, (c) 4800 minims, (d) 6700 grains, (e) 60 fluidrams.

9. Convert the following into cubic centimeters: (a) f.ʒvii, (b) f.℥iv, (c) ♏.lxv, (d) Oii.

10. Change the following to grams: (a) ʒv, (b) ℥ix, (c) gr.xlvii, (d) lb.i.

11. Change to apothecaries': (a) 5.6 Gm., (b) 35 cc., (c) 0.25 Gm., (d) 0.005cc.

12. Convert into metric: (a) gr. $\frac{1}{400}$, (b) gr. $\frac{1}{120}$, (c) gr. $\frac{1}{30}$, (d) gr. $\frac{1}{8}$.

STRENGTH OF SOLUTIONS

1. What is the percentage strength of a pint of solution that contains 5 grains of drug?

2. Determine the ratio strength of 250 cubic centimeters of solution that contains 50 grams of a drug.

3. An ounce of solution contains 2 grams of solute. What is the percentage strength?

4. If two fluidrams of solution contain 0.3 of a gram of a drug, what is the ratio strength of the solution?

5. What is the percentage strength of a solution containing 150 grams of solute in a quart of solution?

6. If 4 fluidrams of solution contain 3 grams of a drug, what is the ratio strength?

7. Change the following to percentage: (a) 1:12$\frac{1}{2}$, (b) 1:20, (c) 1:200, (d) 1:10,000.

8. Change the following to ratio: (a) 33$\frac{1}{3}$ per cent, (b) 0.5 per cent, (c) $\frac{1}{4}$ per cent, (d) 2$\frac{1}{2}$ per cent.

PREPARATION OF SOLUTIONS

1. Calculate the amount of silver nitrate required to make 4 fluidounces of a 1 per cent solution.

2. How many grams of mercuric chloride will be needed to make 2 liters of a $\frac{1}{2}$ per cent solution?

3. How much solute is required to make 3 fluidounces of a 1 per cent solution of potassium permanganate?

4. Find the amount of mercuric chloride needed to make a gallon of a 1:2000 solution.

5. In making a saturated solution of boric acid, how many grams are needed to make a pint of solution?

6. How many fluidounces of compound cresol solution will be needed to make 6 quarts of a 3 per cent solution?

7. Calculate the amount of sodium chloride required to make a quart of physiological salt solution.

8. How would you prepare a pint of 5 per cent sodium hydroxide solution?

9. How many grams of strong silver protein are needed to make 200 cubic centimeters of a 0.75 per cent solution?

10. Calculate the amount of tannic acid needed to make 5 fluidounces of a 0.5 per cent solution.

11. How much of a 10 per cent stock solution of sodium chloride will be needed to make a quart of a physiological salt solution?

12. How much of a saturated solution of potassium permanganate is needed to make 2 liters of a 1:2000 solution?

13. Determine how much of a 1 per cent solution of mercuric oxycyanide is needed to make 250 cubic centimeters of a 1:5000 solution.

14. How much of a 2 per cent solution of silver nitrate is needed to make a pint of a 1:1000 solution?

15. From a 3 per cent solution of tannic acid prepare a fluidounce of a 0.2 per cent solution.

16. Calculate how to make 2 fluidounces of a 10 per cent solution of mild silver protein from a 25 per cent solution.

17. Make 10 cubic centimeters of a 5 per cent argyrol solution from a 50 per cent stock solution.

18. How many cubic centimeters of a 2 per cent solution of chloramine are needed to make 2 fluidounces of a $1\frac{1}{2}$ per cent solution?

19. From a 5 per cent phenol solution make 30 cubic centimeters of a 2 per cent solution.

20. How much of a 4 per cent solution of acriflavine is needed to make 75 cubic centimeters of a 1:1000 solution?

21. How many 5 grain tablets of boric acid are required to make a pint of a 5 per cent solution?

22. Calculate the number of tablets needed to make 2 fluidounces of a 4 per cent solution of potassium chlorate from 0.3 gram tablets.

23. How would you prepare 250 cubic centimeters of a 5 per cent solution of sodium bicarbonate from 10 grain tablets?

24. Determine the number of tablets needed to make 6 fluidrams of a 3 per cent solution of ammonium chloride from 3 grain tablets.

25. How many 2 grain tablets of procaine hydrochloride are required to prepare 3 fluidrams of a 2 per cent solution?

26. In how much water should a 5 grain tablet of sodium bicarbonate be dissolved to make a 5 per cent solution?

27. Determine the amount of water needed to dissolve a 0.5 gram tablet of mercuric chloride to make a 1:1000 solution.

PREPARATION OF DOSES

1. Calculate how much of a gr. $\frac{1}{250}$ tablet of aconitine is needed to prepare a gr. $\frac{1}{400}$ dose.

2. How would you give a gr. $\frac{1}{40}$ dose of digitoxin from tablets of gr. $\frac{1}{100}$?

3. From gr. $\frac{1}{60}$ tablets of atropine sulphate prepare a gr. $\frac{1}{100}$ dose.

4. Make a gr. $\frac{1}{2}$ dose of cocaine hydrochloride from tablets of gr. $\frac{1}{3}$.

5. Prepare a gr. $\frac{3}{4}$ dose of ephedrine sulphate from tablets of $1\frac{1}{2}$ grains.

6. How much of a gr. $\frac{1}{100}$ tablet of hyoscyamine hydrobromide is required for a gr. $\frac{1}{120}$ dose?

7. If directed to give a gr. $\frac{1}{4}$ dose of codeine sulphate, how would you prepare it from tablets of gr. $\frac{1}{2}$?

8. How would you obtain a gr. $\frac{1}{40}$ dose of strychnine sulphate from tablets of gr. $\frac{1}{30}$?

9. Prepare a gr. $\frac{1}{120}$ dose of thyroxin from gr. $\frac{1}{80}$ tablets.

10. Give a gr. $\frac{1}{6}$ dose of morphine sulphate from tablets of gr. $\frac{1}{8}$.

11. From a ♏.x = gr. $\frac{1}{8}$ stock solution of morphine sulphate give a dose of gr. $\frac{1}{12}$.

12. How many minims of stock solution of strychnine sulphate in which ♏.x = gr. $\frac{1}{25}$ are needed to make a gr. $\frac{1}{40}$ dose?

13. Determine the number of minims of Magendie's solution (1:30) required to give a gr. $\frac{1}{4}$ dose of morphine.

14. Make a gr. $\frac{1}{6}$ dose of cocaine hydrochloride from a 2 per cent solution.

15. Prepare a gr. $\frac{1}{80}$ dose of eserine sulphate from a 0.5 per cent solution.

16. From a $\frac{1}{4}$ per cent solution of atropine sulphate prepare a gr. $\frac{1}{120}$ dose.

17. Give a gr. $\frac{1}{3}$ dose of codeine sulphate from a solution in which ♏.x = gr. $\frac{1}{2}$.

18. Determine how much of a 1 per cent solution of hyoscyamine hydrobromide is required to make a gr. $\frac{1}{120}$ dose.

19. How would you prepare a gr. $\frac{1}{6}$ dose of pilocarpine nitrate from a 4 per cent solution?

20. From a solution of strophantin in which ♏.x = gr. $\frac{1}{10}$ make a gr. $\frac{1}{120}$ dose.

21. The adult dose of aromatic fluidextract of cascara sagrada is 2 cubic centimeters. What is the dose for a 10 year old child?

22. Calculate the dose of spirit of peppermint for a child $1\frac{1}{2}$ years of age. The adult dose is 1 cubic centimeter.

$\frac{1}{250} = \frac{1}{h}$ X [illegible]

$\frac{1}{400}$

$\frac{1}{40} = \frac{1}{4}$ X [illegible]

CHAPTER XX

LABORATORY EXERCISES AND DEMONSTRATIONS

Sources of Drugs.
Pharmaceutical Preparations.
Alkaloids.
Fixed and Volatile Oils.
Animal Drugs.
Biological Preparations.
Weights and Measures.
Solution.
Solubility.
Osmotic Pressure.
Solutions from Pure Drugs.
Solutions from Stock Solutions.
Solutions from Tablets.
Antiseptics and Disinfectants.
Needle Doses from Tablets.
Needle Doses from Stock Solutions.

The exercises in this chapter have been devised to give the student first-hand information about drugs, and practice in the use of weights and measures, and the preparation of solutions and doses. Some of the exercises are intended to be used as demonstrations, others may be adapted to such use if circumstances make it impossible to have them performed by the class. It is hoped that the exercises are sufficiently flexible so that they may readily be adapted to meet the requirements of a given class.

Each student should have a laboratory note book in which a record of the work done is to be kept. All questions should be answered as part of the written work. The notes are to be written in ink in a careful manner and submitted to the instructor at the following class period.

EXERCISE I

SOURCES OF DRUGS

Materials Needed:

1. Crude Plant Drugs.—Cascara, digitalis, aconite, cinchona, belladonna, strophanthus, nux vomica, senna, podophyllum, wintergreen, peppermint, hydrastis, hyoscyamus, sandalwood, rhubarb, gentian, jaborandi, aloes, wild cherry, and squill.

2. Coal Tar Drugs.—Coal tar, phenol, cresol, phenolphthalein, cinchophen, salicylic acid, acetylsalicylic acid, and acetanilid.

3. Animal Drugs.—Cod liver oil, pepsin, pancreatin, thyroxin, epinephrine, pituitary extract, insulin, and cantharides.

4. Mineral Drugs.—Crude mineral drugs such as cinnabar and other ores. Salts of the heavy metals, iodine, and other mineral drugs.

5. Synthetic Drugs.—Procaine, arsphenamine, acriflavine, and mercurochrome.

6. Drugs from the Bacteriological Laboratory.—Various vaccines and antisera.

Directions:

1. Examine the crude botanical drugs and become acquainted with their names and appearance.

2. Note the odor and other physical characteristics.

3. Classify these drugs as suggested in the table below.

Leaves	Roots	Bark	Seeds	Wood	Whole herb

4. Examine coal tar and note its odor and physical characters.

5. Examine the more important coal tar products and note their physical characteristics.

6. Examine a chart showing the location of digestive and endocrine glands and determine from which glands the various glandular products have been obtained.

7. Examine other animal drugs and determine their sources.

8. Make a list of animal drugs in your note book and indicate the specific source in each case.

9. Examine the mineral drugs and note their physical characteristics.

10. Examine synthetic drugs and in a general way determine their composition.

11. Examine various vaccines and antisera and learn to distinguish between these two types of preparations.

Questions:

1. Give the common names of, (a) digitalis, (b) hydrastis, (c) podophyllum, (d) hyoscyamus. Use a medical dictionary if necessary.
2. In a medical dictionary look up the complete scientific names of (a) cascara, (b) digitalis, (c) nux vomica, and (d) jaborandi.
3. How are drugs obtained from coal tar?
4. Give the names of drugs obtained from (a) endocrine glands, (b) digestive glands, and (c) other animal sources.
5. Name five mineral drugs and give the source of each one.
6. How are synthetic drugs obtained?
7. Explain how vaccines are made.
8. What is the source of antisera?

EXERCISE II

PHARMACEUTICAL PREPARATIONS

Materials Needed:

1. Drugs to Make Pharmaceutical Preparations.—Zinc oxide, paraffin, white petrolatum, peppermint oil, purified talc, fluidextract

of rhubarb, spirit of cinnamon, potassium carbonate, simple syrup, camphor, alcohol, prepared chalk, glycerin, cinnamon water, cod liver oil, powdered acacia, methyl salicylate, cotton seed oil, tannic acid, sodium citrate, powdered cascara bark.

2. Glassware, Apparatus, Etc.—Graduates, percolator, funnels, mortar and pestle, water bath, filter paper, cotton.

3. Standard pharmaceutical preparations.

Directions:

I. Prepare the following:

1. Ointment of Zinc Oxide, *U.S.P.* Triturate 5 Gm. of finely powdered zinc oxide (free from grit) with about one-fourth of a melted mixture of paraffin (3.75 Gm.) and white petrolatum (16.25 Gm.). Add the remainder of the melted mixture and stir until it congeals. Consult the Pharmacopœia for other methods of making ointments.

2. Peppermint Water, *U.S.P.* Add 0.5 cc. of peppermint oil to a mortar containing about 5 Gm. of purified talc and triturate with the pestle. Volatile oils are only sparingly soluble in water. By triturating with talc the oil is absorbed by the talc and separated into a finely divided form. Add 250 cc. of water gradually and then filter through filter paper.

3. Syrup of Rhubarb, *U.S.P.* Mix 0.5 cc. of spirit of cinnamon with 10 cc. of fluidextract of rhubarb and add 1 Gm. of potassium carbonate dissolved in 5 cc. of water. Add enough simple syrup to make 100 cc.

4. Spirit of Camphor, *U.S.P.* Dissolve 1 Gm. of camphor in 8 cc. of alcohol and then add enough alcohol to make 10 cc. Note the formula in the Pharmacopœia for aromatic spirit of ammonia.

5. Chalk Mixture, *U.S.P.* Triturate 3 Gm. of prepared chalk with 5 cc. of glycerin and 20 cc. of

cinnamon water. Transfer to a graduate, rinse mortar with water and fill graduate to 50 cc. mark.

6. Emulsion of Cod Liver Oil, *U.S.P.* Triturate 50 cc. of cod liver oil with 12.5 Gm. of powdered acacia and 25 cc. of water to an emulsion. Add 0.5 cc. of methyl salicylate, 10 cc. of simple syrup, enough water to make 100 cc. and mix thoroughly.

7. Camphor Liniment, *U.S.P.* (Camphorated Oil). Dissolve 2 Gm. of coarsely powdered camphor in 8 Gm. of cotton seed oil which has been heated on a water-bath.

8. Glycerite of Tannic Acid, *U.S.P.* Dissolve 20 Gm. of tannic acid and 0.25 Gm. of sodium citrate in 19.75 Gm. of glycerin in a bottle by heating on a water-bath.

II. Extraction by Percolation (Demonstration).

1. Weigh 500 Gm. of powdered cascara bark and moisten it in a pan with water.

2. Into the small end of the percolator insert a cork perforated by a short glass tube and attach a piece of rubber tubing about 15 inches long to the glass tube. Set the percolator in a ring stand and fasten the end of the rubber tube to the top of the ring stand.

3. Place a pledget of cotton in the neck of the percolator and cover it with a layer of clean sand over which place a disk of filter paper.

4. Place the moistened drug into the percolator and press it down firmly.

5. Pour the menstruum (water may be used in this case, or 20 per cent alcohol) on the drug so that it will stand several inches above the drug.

6. Cover the percolator and set it aside for several days.

7. Lower the rubber tube and place the end into a jar. Adjust the level of the jar so that the percolate will flow at the rate of about 10 drops per minute.

8. New menstruum must be added from time to time until the drug has been exhausted.

9. If a fluidextract is desired, the first percolate, in this case a little less than 500 cc., is set aside and the rest of the percolate evaporated to a moist mass which is added to the first percolate. Water is then added so that the fluidextract will measure 500 cc.

10. If an extract is desired, the total amount of percolate is evaporated down to a sticky or dry mass.

III. Standard Pharmaceutical Preparations.

1. Examine standard pharmaceutical preparations read the labels, and by referring to Chapter IV determine what each one consists of.

2. Make a list including the name and constituents of each preparation examined.

Questions:

1. Define the term triturate.
2. Why is purified talc used in making aromatic waters.
3. What is simple syrup?
4. What purpose does glycerin serve in chalk mixture?
5. Why is acacia used in making emulsions?

EXERCISE III

ALKALOIDS

Materials Needed:

Belladonna leaves, Prollius' fluid, flask, glass separator, Mayer's reagent or one of the following, tannic acid, picric acid, mercuric chloride.

Directions:

I. Extraction of Alkaloids (Demonstration).

1. Powder a certain number of grams of belladonna leaves, place the powder in a flask, and add about ten times its weight of Prollius' fluid which consists of 325 cc. of ether, 25 cc. of alcohol, and 10 cc. of stronger ammonia water.

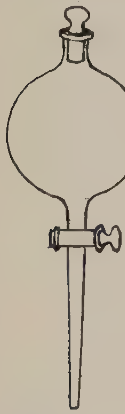

FIG. 28.—Glass separator.

2. Close the flask tightly and agitate frequently.

3. After several hours decant some of the clear fluid into a glass separator containing a 5 per cent sulphuric acid solution. By careful, gentle, rotation any alkaloid present is transferred to the acid solution. Avoid active agitation or emulsion may result which will prevent the alkaloid from being transferred from one liquid to the other.

4. Withdraw the acid from the separator and warm it on a water-bath to remove the ether and alcohol.

II. Test for Alkaloids.

1. Test the solution for the presence of alkaloid as follows: Pour about 1 cc. of the solution into a test tube and add 2 or 3 drops of a solution of either tannic acid, picric acid, mercuric chloride, or Mayer's reagent (a solution of mercuric potassium iodide, see *U.S.P.* p. 490).

2. Describe the visible reaction that occurs. Note: If the extraction of an alkaloid cannot be carried out an acid solution (made acid with dilute H_2SO_4) of

an alkaloid or alkaloidal salt may be tested with the reagents named and the reaction noted.

Questions:

1. What is the purpose of the glass separator in the extraction of alkaloids?
2. What reaction occurs when tannic acid, mercuric chloride, picric acid, or Mayer's reagent are added to a solution containing alkaloids?

EXERCISE IV

FIXED AND VOLATILE OILS

Materials Needed:

Cotton seed oil, filter paper, alcohol, ether, chloroform, sodium hydroxide, table salt, volatile oil.

Directions:

1. Place a drop of cotton seed oil or some other fixed oil on filter paper. Warm over the Bunsen flame. Does heat remove the stain?
2. Add a few drops to water in a test tube. Is it soluble in water?
3. Add a few drops to alcohol. Is it soluble in alcohol?
4. Determine whether it is soluble in ether or chloroform?
5. Add about 5 cc. of the oil to 10 cc. of a 10 per cent solution of sodium hydroxide. Boil until it becomes transparent. What has occurred?
6. Add salt to the solution. Explain the results.
7. Place a drop of a volatile oil on filter paper. Warm over a Bunsen flame. Does the stain disappear?
8. Determine whether the volatile oil is greasy.

9. Add a few drops to water in a test tube. Is it soluble?
10. Determine whether it is soluble in alcohol.

Questions:

1. Compare fixed oils with volatile oils.
2. State the chief characteristics of (a) fixed oils, (b) volatile oils.

EXERCISE V

ANIMAL DRUGS

Materials Needed:

Pepsin, pancreatin, thyroid, thyroxin, epinephrine, pituitary extract, insulin, bile salts, cantharides, cod liver oil.

Directions:

1. Examine each preparation and note its nature.
2. Among the glandular products determine the specific gland from which each one was obtained.

Questions:

1. Which of the above preparations are active principles?
2. Name those obtained from digestive glands.
3. What enzymes are present in pancreatin?
4. Name the preparations obtained from endocrine glands.
5. What is cantharides?

EXERCISE VI

BIOLOGICAL PREPARATIONS

Materials Needed:

Vaccines, antitoxins and other antisera, pollen extracts.

Directions:

Examine each preparation and determine how it was prepared.

Questions:

1. What is a vaccine?
2. How did the practice of vaccination originate?
3. Name diseases in which vaccines are used.
4. What are antisera? How are they obtained?
5. Name diseases in which antisera are used?
6. What therapeutic use is made of pollen extracts?

EXERCISE VII

WEIGHTS AND MEASURES

Materials Needed:

Balances, metric and apothecaries' weights, graduates, sodium chloride, meter sticks.

Directions:

1. Measure the length of your pencil in millimeters and centimeters.

2. Measure the length of the table in decimeters and meters.

3. Draw a cubic decimeter. Which unit was obtained from the cubic decimeter?

4. Draw a cubic centimeter. Which unit was obtained from the cubic centimeter?

5. Weigh a cubic centimeter of water. How much does it weigh?

6. Weigh the following amounts of sodium chloride 1 Gm., 3.5 Gm., 0.1 Gm., 15 Gm., ʒi, gr.i, ℥i, gr.xv.

7. Determine the weight in the metric system of gr.xv, ʒi, ℥i.

8. In a graduate measure the following amounts of water: 1 cc., 7.5 cc., 0.5 cc., f.ʒi, f℥i, fʒviii, f℥xvi, Oi, ♏.v.

9. With a medicine dropper place 10 drops of water in a minim graduate and read the graduate.

Repeat this with alcohol, a fixed oil, a volatile oil, and glycerin, and note the reading in each case.

10. Measure a fluidram of water in a metric graduate and determine what it is equivalent to in cubic centimeters. Repeat this with 1 fluidounce, 1 pint, 1 quart, and 15 minims.

Questions:

1. How was the metric unit of volume obtained? The unit of weight?
2. What is the weight of a cubic centimeter of water in grams?
3. Give the approximate weight of each of the following in the metric system: gr.xv, ʒi, ℥i.
4. Give the approximate number of cubic centimeters in each of the following: f ʒi, f ℥i, Oi, qt.i, ♏.xv.
5. How do drops of water, alcohol, fixed oils, volatile oils, and glycerin compare in size? Is a drop a minim?

EXERCISE VIII

SOLUTION

Materials Needed:

Sodium chloride, powdered chalk, ammonium carbonate, acetic acid, test tubes.

Directions:

1. Place a few grains of sodium chloride into a test tube containing water. Agitate and note the results.

2. Repeat the above using powdered chalk in place of sodium chloride.

3. Observe both preparations after standing for five minutes. Explain the results.

4. Weigh 20 Gm. of sodium chloride and place it in a cc. graduate to determine its volume. Add 100 cc. of water. Is the total amount of solution equal to the sum of the volumes of the solute and solvent?

5. The following solution may be made by the instructor to demonstrate a chemical solution:

Solution of Ammonium Acetate, U.S.P.

Ammonium carbonate	5 Gm.
Acetic acid (15 per cent solution)	100 cc.

The acetic acid combines with ammonium carbonate which results in the formation of ammonium acetate, carbon dioxide, and water.

Questions:

1. Define solution.
2. What changes take place when a substance goes into solution?
3. How does a mixture differ from a solution?
4. What is meant by (a) simple solution, (b) chemical solution?

EXERCISE IX

SOLUBILITY

Materials Needed:

Boric acid, iodine crystals, alcohol, glycerin, ferric chloride, lactose, solution of potassium iodide, test tubes.

Directions:

1. Place some iodine crystals in a test tube of water and agitate. Repeat using alcohol instead of water.

2. Add iodine crystals to an aqueous solution of potassium iodide. Explain the results.

3. Add a few drops of glycerin to water. Is it soluble?

4. Add 5 Gm. of ferric chloride to 1 cc. of water. Does all of it dissolve?

5. Dissolve 5 Gm. of lactose in 20 cc. of water. Add a few more grams of lactose. Does it dissolve?

6. Into each of two test tubes containing 20 cc. of water place 1 Gm. of boric acid. Heat one of the

tubes in the Bunsen flame and agitate both tubes. Explain the results.

7. Add another gram of boric acid and apply heat. Does it dissolve? Cool it under the faucet and explain the results.

Questions:

1. Is iodine soluble in (a) water, (b) alcohol, (c) aqueous solution of potassium iodide?
2. How does heat affect solubility?
3. What is a saturated solution?
4. What did you learn about the limit of solubility in this exercise?

EXERCISE X

OSMOTIC PRESSURE

Materials Needed:

Diffusion shells, glass jars, ring stands, sodium chloride, glycerin, blood.

Directions:

Note: This exercise may be demonstrated by the instructor.

1. Fill a diffusion shell with a 10 per cent solution of sodium chloride. Insert a long glass tube through a hole in a rubber stopper and fasten the shell tightly to the rubber stopper.

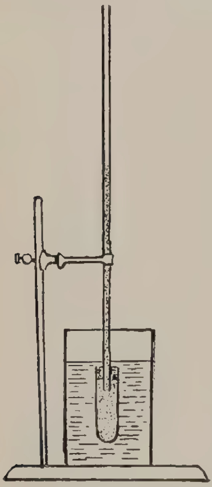

FIG. 29.—Osmotic pressure apparatus.

2. Clamp the tube to a ring stand so that the shell will be immersed in a jar of water.

3. Fill a second shell with a 16 per cent glycerin solution and set up as directed above. A 16 per cent glycerin solution has the same molecular concentration per cc. as a 10 per cent solution of sodium chloride.

4. Let stand for several hours or overnight and note results.

5. Place some red blood corpuscles in a 10 per cent solution of sodium chloride for a few minutes and examine under a miscroscope. Compare with red blood corpuscles that have not been placed in salt solution.

Questions:

1. Define (a) osmotic pressure, (b) osmosis.
2. Which of the solutions used exerted the greater osmotic pressure?
3. Since the molecular concentration was the same in each solution how do you account for the difference in osmotic pressure?
4. Explain what occurred when red blood corpuscles were placed in salt solution.

EXERCISE XI

PREPARATION OF SOLUTIONS FROM PURE DRUGS

Materials Needed:

Sodium bicarbonate, alum, boric acid, glycerin, sodium chloride, potassium permanganate, mild protargin, tannic acid, zinc sulphate, compound cresol solution, balances, graduates, stirring rods, funnels, cotton.

Directions:

Prepare the following solutions:

Solution to Make	Amount	Strength
1. Sodium bicarbonate	f.℥viii	6 per cent
2. Alum	f.℥iii	4 per cent
3. Boric acid (use hot water)	250 cc.	5 per cent
4. Glycerin	f.℥i	20 per cent
5. Sodium chloride	1.5 L.	0.85 per cent
6. Potassium permanganate	Oi	1:1000
7. Mild protargin	f.ʒi	20 per cent
8. Tannic acid	f.℥iii	0.2 per cent
9. Zinc sulphate	f.℥vi	0.5 per cent
10. Compound cresol solution (dilution of)	f.℥iv	3 per cent

Note: Filter each solution through cotton after it has been prepared.

EXERCISE XII

PREPARATION OF SOLUTIONS FROM STOCK SOLUTIONS

Materials Needed:

1. The following stock solutions:
    - (a) Phenol 6 per cent.
    - (b) Sodium chloride 25 per cent.
    - (c) Mercuric chloride 5 per cent.
    - (d) Sodium bicarbonate 10 per cent.
    - (e) Magnesium sulphate 50 per cent.
    - (f) Zinc sulphate 10 per cent.
    - (g) Tannic acid 50 per cent.
    - (h) Potassium carbonate 2 per cent.
    - (i) Alum 50 per cent.
    - (j) Potassium permanganate 6 per cent.
2. Graduates, stirring rods.

Directions:

Prepare the following solutions:

	Solution to Make	Amount	Strength	From Stock Solution
1.	Phenol	350 cc.	0.5 per cent	6 per cent
2.	Sodium chloride	100 cc.	0.85 per cent	25 per cent
3.	Mercuric chloride	Oi	1:2000	5 per cent
4.	Sodium bicarbonate	f.℥viii	4 per cent	10 per cent
5.	Magnesium sulphate	f.℥iv	20 per cent	50 per cent
6.	Zinc sulphate	150 cc.	1 per cent	10 per cent
7.	Tannic acid	250 cc.	5 per cent	50 per cent
8.	Potassium carbonate	f.℥ii	0.2 per cent	2 per cent
9.	Alum	f.℥i	1 per cent	50 per cent
10.	Potassium permanganate	200 cc.	1:1000	6 per cent

EXERCISE XIII

PREPARATION OF SOLUTIONS FROM TABLETS

Materials Needed:

1. The following tablets:
    - (a) Mercuric chloride gr.viiss.
    - (b) Boric acid gr.v.

(c) Potassium chlorate 0.5 Gm.
(d) Sodium bicarbonate gr.x.
(e) Potassium permanganate 0.2 Gm.
(f) Potassium iodide gr.i.
(g) Ammonium chloride gr.iii.
(h) Chloramine gr.v.
(i) Sodium chloride 2 Gm.
(j) Sodium cacodylate gr.v.

2. Graduates, stirring rods.

Directions:

Prepare the following solutions:

Solution to Make	Amount	Strength	Strength of Tablet
1. Mercuric chloride...........	1 L.	1:1000	gr.viiss
2. Boric acid..................	f. ʒx	2½ per cent	gr.v
3. Potassium chlorate..........	f.ʒiii	4 per cent	0.5 Gm.
4. Sodium bicarbonate.........	f. ʒv	10 per cent	gr.x
5. Potassium permanganate....	200 cc.	1:1000	0.2 Gm.
6. Potassium iodide............	f.ʒi	10 per cent	gr.i
7. Ammonium chloride.........	f.ʒiv	5 per cent	gr.iii
8. Chloramine.................	50 cc.	2 per cent	gr.v
9. Sodium chloride (use one tablet and calculate solvent)..		0.85 per cent	2 Gm.
10. Sodium cacodylate (use one tablet and calculate solvent)		5 per cent	gr.v

EXERCISE XIV

ANTISEPTICS AND DISINFECTANTS

Materials Needed:

1. The following agents in pure form: Mercuric chloride, mercurochrome, silver nitrate, colloidal silver preparation, chlorinated lime, chloramine, dichloramine, iodine, iodoform, thymol iodide, phenol, cresol, acriflavine, gentian violet, potassium permanganate, menthol, thymol, eucalyptol, boric acid, alcohol, lime.

2. The following solutions: Dakin's solution, Labarraque's solution, tincture of iodine, Lugol's solution, liquefied phenol, glycerite of phenol, compound cresol solution, hydrogen peroxide, milk of lime,

formaldehyde, phenol 6 per cent, mercuric chloride 1:1000, silver nitrate 10 per cent.

3. White of one egg dissolved in 100 cc. of water.

Directions:

1. Examine various agents in pure form and describe each one.
2. Place a few cubic centimeters of egg albumin solution in each of four test tubes.
3. Add a few drops of a 6 per cent phenol solution to one of the tubes and explain the results.
4. Test the remaining tubes in a similar way with, alcohol, 1:1000 mercuric chloride solution, and 10 per cent silver nitrate solution.

Questions:

1. Name antiseptic agents that are in the liquid state in pure form.
2. Of what do colloidal silver preparations consist?
3. Give the sources of menthol, thymol, and eucalyptol.
4. How is compound cresol solution made?
5. Name the constituents of tincture of iodine.
6. What is liquefied phenol?
7. What is lime chemically?
8. What is milk of lime?

EXERCISE XV

PREPARATION OF NEEDLE DOSES FROM TABLETS

Materials Needed:

1. Tablets:—
   - (a) Atropine sulphate gr. $\frac{1}{100}$.
   - (b) Digitoxin gr. $\frac{1}{100}$.
   - (c) Hyoscyamine hydrobromide gr. $\frac{1}{120}$.
   - (d) Strophantin gr. $\frac{1}{150}$.
   - (e) Pilocarpine nitrate gr. $\frac{1}{10}$.
   - (f) Strychnine sulphate gr. $\frac{1}{15}$.

- (g) Nitroglycerine gr. $\frac{1}{50}$.
- (h) Sodium cacodylate 0.2 Gm.
- (i) Thyroxin gr. $\frac{1}{60}$
- (j) Emetine hydrochloride 0.015 Gm.

2. Syringes, needles, distilled water.

Directions:

Prepare the following doses:

	Drug	Dose	Strength of Tablet
1.	Atropine sulphate	gr. $\frac{1}{140}$	gr. $\frac{1}{100}$
2.	Digitoxin	gr. $\frac{1}{120}$	gr. $\frac{1}{100}$
3.	Hyoscyamine hydrobromide	gr. $\frac{1}{100}$	gr. $\frac{1}{120}$
4.	Strophantin	gr. $\frac{1}{120}$	gr. $\frac{1}{150}$
5.	Pilocarpine nitrate	gr. $\frac{1}{12}$	gr. $\frac{1}{10}$
6.	Strychnine sulphate	gr. $\frac{1}{30}$	gr. $\frac{1}{15}$
7.	Nitroglycerin	gr. $\frac{1}{250}$	gr. $\frac{1}{50}$
8.	Sodium cacodylate	0.06 Gm.	0.2 Gm.
9.	Thyroxin	gr. $\frac{1}{100}$	gr. $\frac{1}{60}$
10.	Emetine hydrochloride	0.02 Gm.	0.015 Gm

EXERCISE XVI

PREPARATION OF NEEDLE DOSES FROM STOCK SOLUTIONS

Materials Needed:

1. Stock solutions:—
   - (a) Strychnine sulphate, ♏.x = gr. $\frac{1}{30}$.
   - (b) Atropine sulphate, 0.5 per cent.
   - (c) Caffeine sodio-benzoate, 25 per cent.
   - (d) Eserine sulphate, $\frac{1}{2}$ per cent.
   - (e) Hyoscyamus hydrobromide, ♏.x = gr. $\frac{1}{10}$.
   - (f) Pilocarpine nitrate, ♏.x = gr.iss.
   - (g) Strophantin, 0.5 per cent.
   - (h) Emetine hydrochloride 5 per cent.
   - (i) Sodium cacodylate ♏.x = gr.ii.
   - (j) Nitroglycerin 1 per cent.
2. Syringes, needles, distilled water.

Directions:

Prepare the following doses:

Drug	Dose	Strength of Stock Solution
1. Strychnine sulphate	gr. $\frac{1}{120}$	♏.x = gr. $\frac{1}{30}$
2. Atropine sulphate	gr. $\frac{1}{120}$	0.5 per cent
3. Caffeine sodio-benzoate	0.2 Gm.	25 per cent
4. Eserine sulphate	gr. $\frac{1}{60}$	$\frac{1}{2}$ per cent
5. Hyoscyamus hydrobromide	gr. $\frac{1}{120}$	♏.x = gr. $\frac{1}{10}$
6. Pilocarpine nitrate	gr. $\frac{1}{12}$	♏.x = gr.iss
7. Strophantin	gr. $\frac{1}{120}$	0.5 per cent
8. Emetine hydrochloride	0.02 Gm.	5 per cent
9. Sodium cacodylate	gr. $\frac{1}{2}$	♏.x = gr.ii
10. Nitroglycerin	gr. $\frac{1}{250}$	1 per cent

APPENDIX

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F

Blumgarten

0 (below freez

Farenheit Scale	Centigrade x
Freezing Point 32	Freezing 0
Boiling 212	Boiling 100

180° between Boil + Freez point
1° = 5/9

To Convert F to C
Subtract 32 + multiply by 5/9

Multiply by 9/5
add 32.

102 F
32
70° C to F